LONG POND

BELGRADE, MOUNT VERNON, & ROME, MAINE

WATERSHED-BASED MANAGEMENT PLAN

(2022-2032)

MARCH 2022

LONG POND WATERSHED-BASED MANAGEMENT PLAN

Prepared for:

Belgrade Lakes Association

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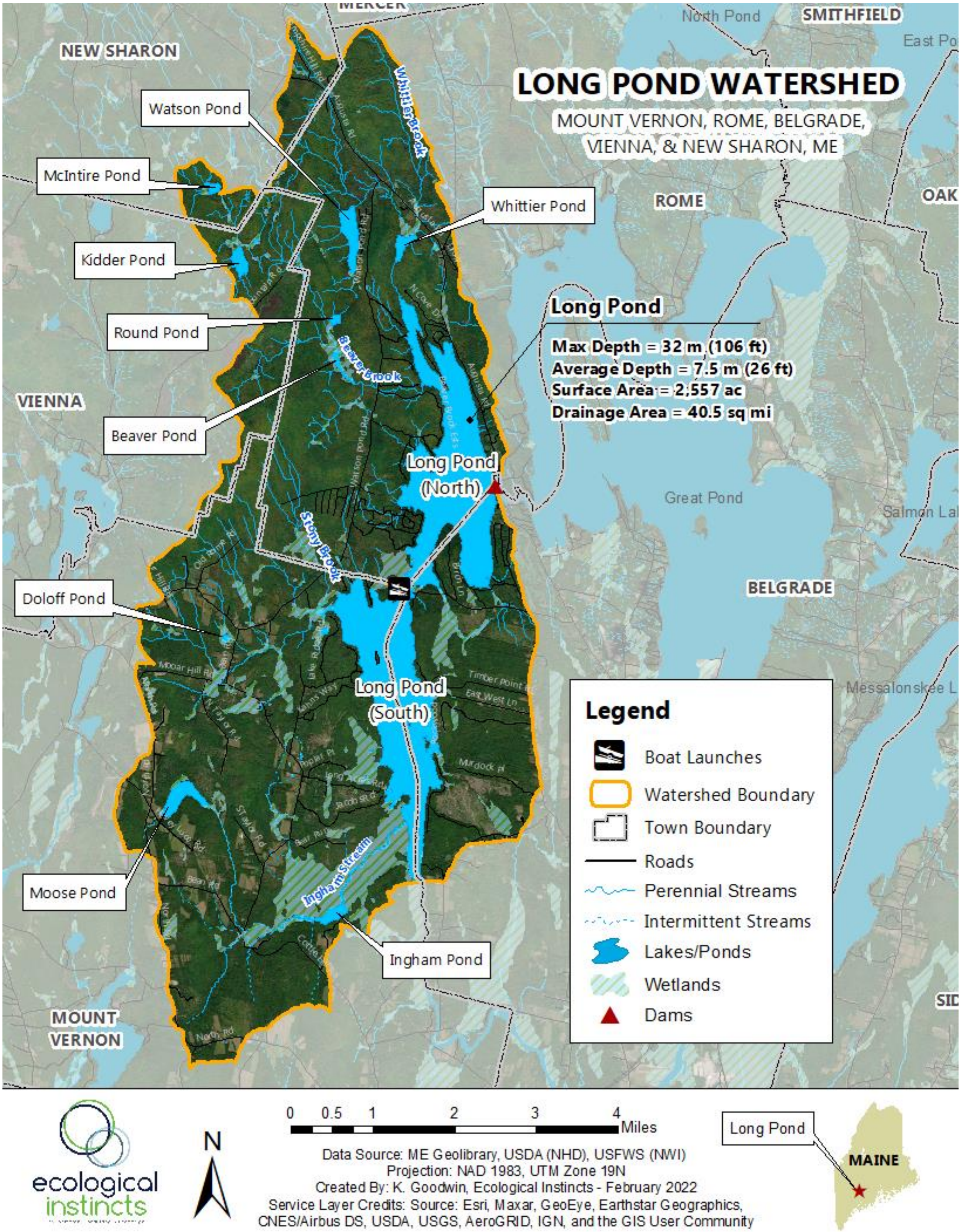
Cover Photo: *Aerial view of Long Pond at Castle Island Rd. (view south)*
Photo Credit: *Alex Wall*


LONG POND WATERSHED
MOUNT VERNON, ROME, BELGRADE, VIENNA, & NEW SHARON, ME
Long Pond
Max Depth = 32 m (106 ft)
Average Depth = 7.5 m (26 ft)
Surface Area = 2,557 ac
Drainage Area = 40.5 sq mi
Watson Pond
McIntire Pond
Kidder Pond
Round Pond
Beaver Pond
Whittier Pond
Doloff Pond
Moose Pond
Ingham Pond
Long Pond (North)
Long Pond (South)
Whittier Brook
Beaver Brook
Stony Brook
Ingham Stream
NEW SHARON
VIENNA
ROME
BELGRADE
MOUNT VERNON
SMITHFIELD
North Pond
Great Pond
Legend
Boat Launches
Watershed Boundary
Town Boundary
Roads
Perennial Streams
Intermittent Streams
Lakes/Ponds
Wetlands
Dams
0 0.5 1 2 3 4 Miles
N
Long Pond
MAINE
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - February 2022
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
ecological instincts

Acknowledgments

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Long Pond WBMP Steering Committee

George Atkinson	Belgrade Lakes Association
Linda Bacon	Maine Department of Environmental Protection
Charlie Baeder	7 Lakes Alliance
Andy Cook	Belgrade Lakes Association
Laura Rose Day	7 Lakes Alliance
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Commonly Used Acronyms

The following are used throughout this document:

7 LAKES	7 Lakes Alliance
BLA	Belgrade Lakes Association
BMP	Best Management Practice
Chl-a	Chlorophyll a
DO	Dissolved Oxygen
Gloeo	*Gloeotrichia echinulata*
KCSWCD	Kennebec County Soil & Water Conservation District
Maine DEP	Maine Department of Environmental Protection
NPS	Nonpoint Source (Pollution)
ppb	Parts Per Billion
ppm	Parts Per Million
SDT	Secchi Disk Transparency
TP/P	Total Phosphorus/Phosphorus
US EPA	United States Environmental Protection Agency
WBMP	Watershed-Based Management Plan

LONG POND WATERSHED-BASED MANAGEMENT PLAN (2022-2032)

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Executive Summary

PURPOSE

The 2022 Long Pond Watershed-Based Management Plan (WBMP) provides details about current water quality conditions, watershed characteristics, and steps that can be taken to restore water quality in Long Pond over the next 10 years. The update supersedes the previous WBMP developed by Kennebec County Soil & Water Conservation District (KCSWCD) in 2009. Implementation is estimated to cost $1.66 million through state, federal and local contributions over this time period. The plan outlines management strategies and an activity schedule (2022 – 2032), establishes water quality goals and objectives, and describes actions needed to achieve these goals. This includes strategies to:

1. **Reduce the external phosphorus load** by addressing existing nonpoint source (NPS) pollution in the direct watershed of Long Pond and the indirect watersheds including Great Pond;
2. **Prevent new sources** of NPS pollution from getting into Long Pond by addressing new NPS sites through land conservation, municipal ordinances and enforcement that address existing and future development, and climate change adaptation;
3. **Raise public awareness** about lake restoration strategies by increasing local education, outreach, and communication efforts to increase participation among municipalities and watershed residents;
4. **Build local capacity** through partnership building across multiple community groups, engaging steering committee members, and developing a robust fundraising strategy;
5. **Monitor and assess improvements** in Long Pond's water quality over time. This includes annual baseline monitoring, documenting changes in internal loading, assessing the current state of septic systems, tracking NPS pollution, conducting stream monitoring, and monitoring for invasive aquatic plants.

THE GOAL

A team of scientists and local stakeholders worked collaboratively over several months to set a revised water quality goal for Long Pond that would help restore water quality and reverse the long-term trend of declining water clarity. Findings from this evaluation of current water quality data and watershed (phosphorus) modeling align with the findings of the 2009 WBMP - that reducing phosphorus (P) loading from the direct watershed of Long Pond alone will not achieve desired water quality conditions due to the dominant influence of P loading from the indirect watersheds.

What P load reductions are needed to meet the goal?

The influence of the P load from Great Pond on the water quality in the north (upper) basin, and similarly, the influence of the water quality in the north basin on the south (lower) basin is one of the most important considerations for restoring the water quality in Long Pond. Therefore, anything that is done to reduce P inputs from reaching the north basin (via Great Pond) will help improve water quality in both basins.

Reducing the P load by 86 kg/yr in the north basin, and by 38 kg/yr in the south basin by addressing NPS pollution on developed land in the direct and indirect watersheds of Long Pond is expected to reduce the average in-lake total P concentration by 0.5 ppb (currently 8.3 ppb in both basins). Phosphorus loading from future development and climate change over the next 10 years is expected to add 0.3 ppb to the average P concentration in the north basin and 0.1 ppb to the south basin. This means that the target in-lake P concentration goals for the plan will be 8.1 ppb in the north basin and 7.9 ppb in the south basin. These are desirable targets to restore water quality and are achievable by addressing the external load from both direct and indirect watersheds.

"P" REDUCTIONS NEEDED

North Basin: - 86 kg/yr
16 kg/yr direct watershed
56 kg/yr indirect watersheds
14 kg/yr septic systems

South Basin: - 38 kg/yr
22 kg/yr direct watershed
10 kg/yr indirect watersheds
6 kg/yr septic systems

Timeframe: 2022- 2032

Projects: Erosion Control BMPs, YCC, LakeSmart, septic upgrades

WATER QUALITY RESTORATION GOAL

Long Pond has stable or improving water quality trends

In-Lake Phosphorus (North Basin) = 8.1 ppb

In-Lake Phosphorus (South Basin) = 7.9 ppb

Planned external load reductions are 38 kg/yr from developed land including shoreline development, roads, and agriculture in the direct watershed of Long Pond, 20 kg/yr from septic systems, plus an additional 56 kg/yr in the north basin by addressing runoff from the indirect watersheds of the north basin, and 10 kg/yr by addressing runoff from the Ingham Pond indirect watershed that drains to the south basin.

What actions are needed to achieve the goal?

The Long Pond WBMP outlines 92 individual action items within five core planning categories to achieve the water quality goal. This includes efforts to address NPS pollution throughout the watershed. Planning recommendations, developed with input from the project's steering committee, are outlined in the plan. The action plan provides current, science-based solutions for restoring water quality in Long Pond while simultaneously promoting communication between residents, watershed towns, and watershed groups including 7 Lakes Alliance and Belgrade Lakes Alliance (BLA). The action plan outlines pollution reduction targets, responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each of the five categories.

How will the plan be funded?

A sustainable funding strategy is needed within the first year that includes diverse funding sources to carry out planned implementation activities. The majority of fundraising will be completed by 7 Lakes Alliance in partnership with BLA. The combined resources of state, federal, and local grants, and contributions from watershed towns, private landowners, and lake association members will be needed to support watershed implementation projects that reduce P from the direct watershed of Long Pond and upstream watersheds. The funding strategy will be revisited on at least an annual basis by an engaged steering committee. The action plan (Sections 7 & 8) is divided into five major planning objectives. The estimated load reductions and estimated costs to complete the work are presented below:

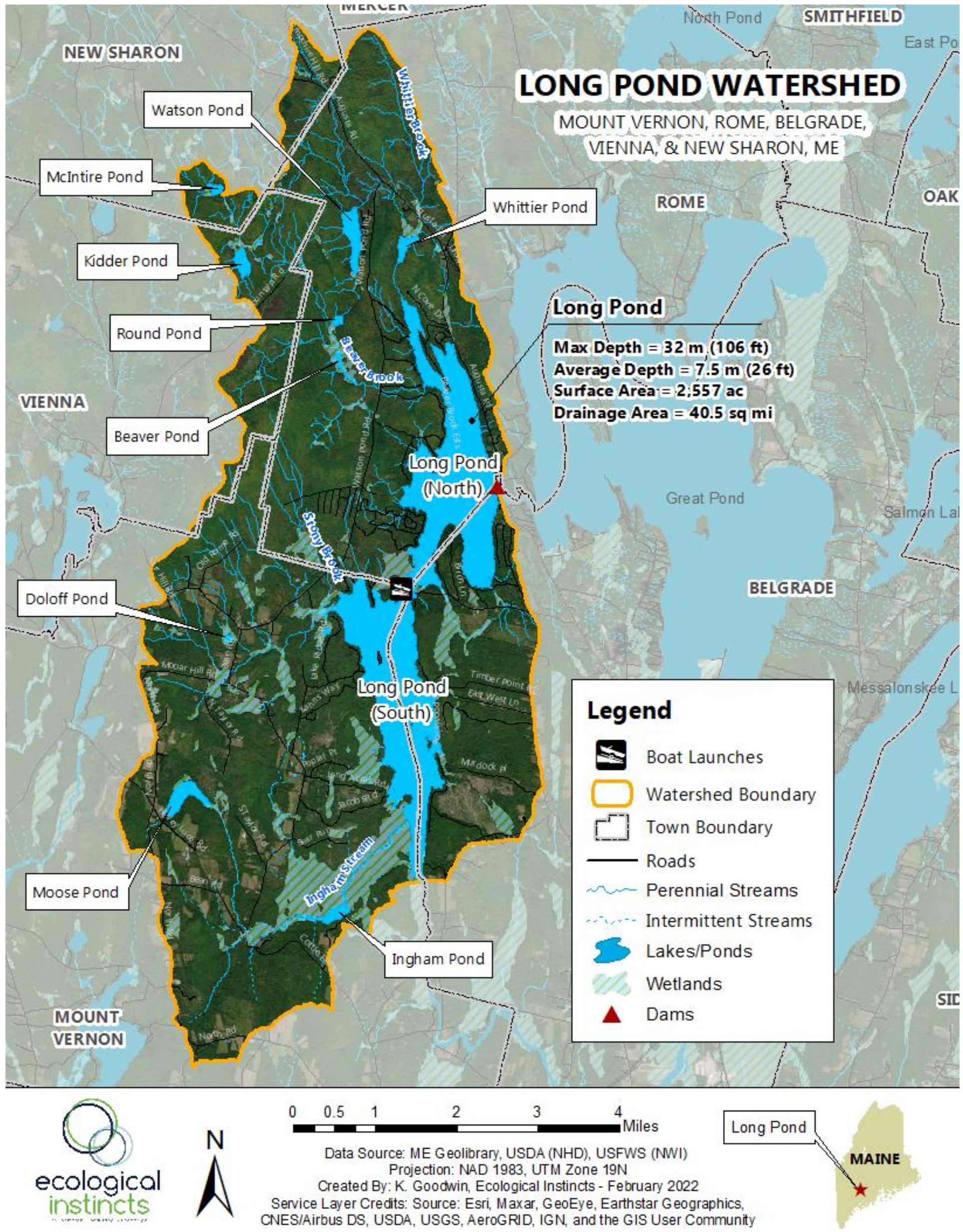
Planning Objective	Planning Action (2022-2032)	P Load Reduction Target	Cost
1	**Reduce the External P Load** (NPS sites, septic systems, LakeSmart, buffer campaign, indirect watersheds)	124 kg/yr	$736,200
2	**Prevent New Sources of NPS Pollution** (NPS sites, land conservation, ordinances, enforcement, climate change adaptation)	n/a	$318,500
3	**Education, Outreach & Communications** (Public meetings, targeted outreach, online videos, buffer campaign, LakeSmart, workshops, economic value, etc.)	n/a	$151,500
4	**Build Local Capacity** (Funding plan, steering committee, grant writing, relationship building- including Town government, contractors and scientists)	n/a	$82,000
5	**Long-Term Monitoring & Assessment** (Baseline monitoring, internal loading, septic systems, NPS pollution, stream monitoring, invasive plants)	n/a	$368,500
	TOTAL	**124 kg/yr**	**$1,656,700**

How will success be measured?

Environmental, social, and programmatic milestones were developed to reflect how well implementation activities are working and provide a means by which to track progress toward the established goals (Section 9). The steering committee will review the milestones on an annual basis, at a minimum, to determine if progress is being made, and then determine if the watershed plan needs to be revised if the targets, including a stable or decreasing P concentration are not being met.

THE LAKE & WATERSHED

Long Pond (MIDAS 5272)[1] is a 2,557-acre lake (Class GPA)[2] located in Kennebec County, in the central Maine towns of Belgrade, Mount Vernon, and Rome (see map to right).



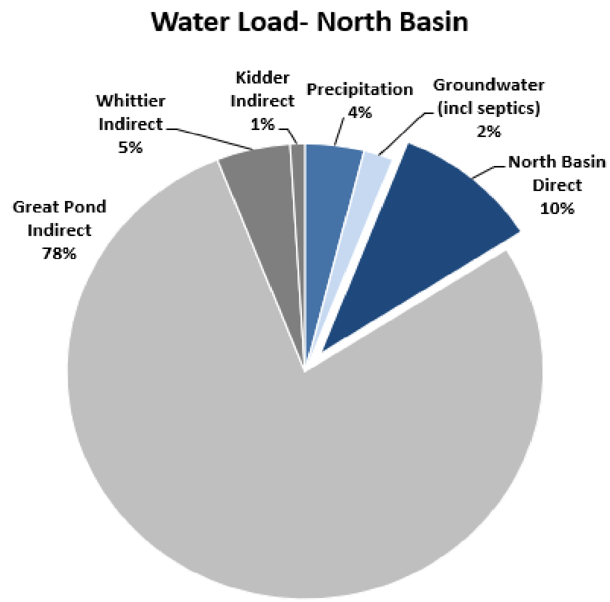
The lake is a naturally formed dual-basin waterbody, with the north basin separated from the south basin by the narrows at Castle Island Rd. in Belgrade. Long Pond is located in the southwest region of the larger Belgrade Lakes watershed and is sixth in the chain of seven Belgrade Lakes.

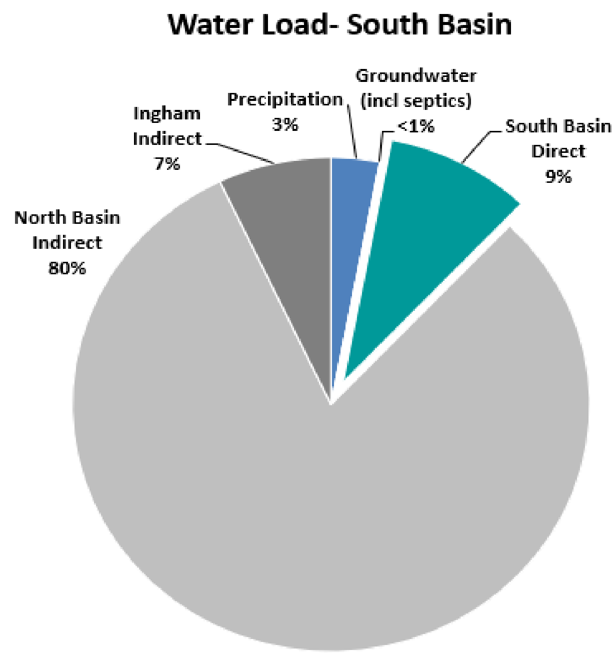
There are five towns in the watershed with Mount Vernon making up the largest land area (44%) followed by Rome (33%), Belgrade (15%), Vienna (6%), and New Sharon (3%). The watershed drains about 41 square miles of the surrounding landscape. The entire watershed area, which includes the indirect watershed of Great Pond to the east, covers 86 square miles and includes nine other small ponds including McIntire Pond, Kidder Pond, Round Pond, Beaver Pond, Watson Pond, Whittier Pond, Doloff Pond, Moose Pond, and Ingham Pond.

[1] The unique 4-digit code assigned to a lake.

[2] Defined by MRSA Title 38 §465-A, Maine Standards for Classification of Lakes and Ponds: Class GPA is the sole classification of Great Ponds (>10 acres) and natural lakes and ponds <10 acres in size.

The watershed includes 95 miles of streams, 1,943 acres of wetlands, and 3,926 acres of riparian habitat along the edges of lakes, ponds, streams, and wetlands. Approximately 84% of the annual water flow into the north basin of Long Pond comes from the watersheds of the upstream lakes, with Great Pond accounting for 78% of the water load (top right). Similarly, the annual water load to the south basin is dominated by inflow from upstream waterbodies, with 80% of the water load to the south basin flowing in from the north basin (bottom right). Long Pond drains into Belgrade Stream which flows over the Wings Mill Dam and downstream to Messalonskee Lake, the last lake in the Belgrade Lakes chain, before draining to the Kennebec River and eventually into the Gulf of Maine.





The maximum depth of the south basin is 31 m (106 ft). The north basin is shallower, with a maximum depth of 18 m (60 ft). The average depth of Long Pond is 11 m (35 ft). The flushing rate of Long Pond is 3.2 flushes/yr in the north basin, and 4.9 flushes/yr in the south basin.[3] The elevation of the lake is 250 ft above sea level while the highest point in the watershed is 1,289-foot McGaffey Mountain in the northwest corner of the watershed, part of the Kennebec Highlands.

What is the current status of development in the watershed?

A 2007 Colby study reported 393 houses on the shoreline of Long Pond, with 68% on the shoreline of the north basin. In 2009, a build-out analysis estimated a total of 618 buildings within the watershed (FBE, 2009a), with development primarily located along the shoreline. An updated land cover analysis shows that forestland makes up the majority of the watershed (77%). Developed land (e.g., residential, commercial, roads) accounts for approximately 7% of the land area in the watershed, followed by agriculture at 5%. Wetlands and open water (not including the surface area of Long Pond) account for the remaining 11% of the watershed area.

[3] The flushing rate in Long Pond is considered high compared to the statewide average of 1 – 1.5 flushes/yr.

There are 86 miles of roads (~500 acres) in the watershed, the majority (59%) of which are unpaved gravel roads (51 miles)[4] that service high-density residential development along the shoreline. The remaining 41% (35 miles) of roads are paved, including Augusta Rd. (Rt. 27) and West Rd. that provide access to the eastern shore of Long Pond; Castle Island Rd. that runs east/west between the two basins of Long Pond; Watson Pond Rd. and Bean Rd. that provide access to the Kennebec Highlands and to the western shore of Long Pond; and several other paved roads in the outer watershed. Commercial development is primarily limited to Belgrade Lakes Village and Rt. 27 as well as Castle Island Camps.

Conservation land is a prominent feature of the watershed, with approximately 24% (5,644 acres) of the watershed permanently protected from development, the majority of which is conserved land associated in the Kennebec Highlands (Vienna, New Sharon, Rome, and Mount Vernon).

THE PROBLEM

Long Pond is renowned as a quintessential Maine lake for its rural character, sweeping lake and mountain views, clear, cool water good for recreation during all seasons, and a healthy fishery. However, this jewel within the Belgrade Lakes area has been showing signs that water quality may be in declining. In 2006, the Maine Department of Environmental Protection (Maine DEP) added Long Pond to the state's list of impaired lakes due to a decline in water clarity of 1 meter over a 30-year period beginning around 1990. Other signs that changes in water quality are occurring include an increased presence of metaphyton and the cyanobacterium *Gloeotrichia echinulata*.

A significant decreasing trend in water clarity has been documented in Long Pond since 1970.

Water quality data have been collected at the deepest location in each basin by Maine DEP and Lake Stewards of Maine (formerly the Volunteer Lake Monitoring Program) in cooperation with BLA since 1970. More recent, intensive monitoring has been completed by 7 Lakes Alliance and Colby College (2015-present). These data were used to conduct a water quality trend analysis for the north and south basins of Long Pond including long-term (1970 – 2021) and short-term trends (last 10-years).

What are the trends?

Results of the water quality trends analysis indicate a weak, but significant decrease in average annual water clarity (lower water clarity over time) in both the north and south basins of Long Pond with the worst readings in the 2000s. However, **over the last 10 years water clarity has stabilized**, averaging

[4] The % of gravel vs. paved roads was calculated by Charlie Baeder, 7 Lakes Alliance, February 2022.

6.2 m in the north basin, and 6.0 m in the south basin. The other significant finding from this analysis was a **decrease in total phosphorus in the south basin** of Long Pond over the last 10 years. The ten-year average annual in-lake phosphorus (P) concentration is 8.3 ppb in both basins of Long Pond. Low levels of dissolved oxygen have been documented in the deepest areas of the lake and the volume of water and the length of time the lake is experiencing low or no oxygen in the north basin has increased slightly between 1989 – 2018. Anoxia (no oxygen) results in a release of P from the bottom sediments during the summer, however this is not currently a concern for Long Pond.

LONG POND WATER QUALITY TRENDS

LONG-TERM (1970-2021)

→ Decline in water clarity in the north and south basins

→ Increase in Anoxic Factor in the north basin

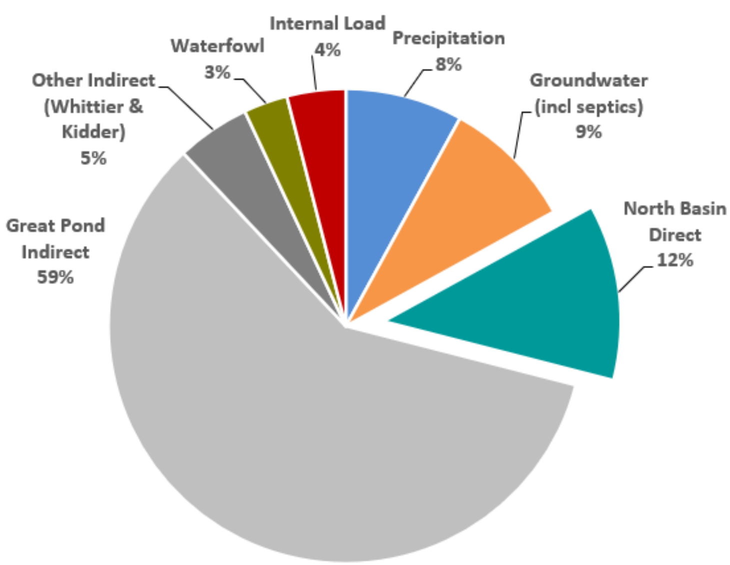
SHORT-TERM (2011-2020)

→ Stable water clarity in north and south basins

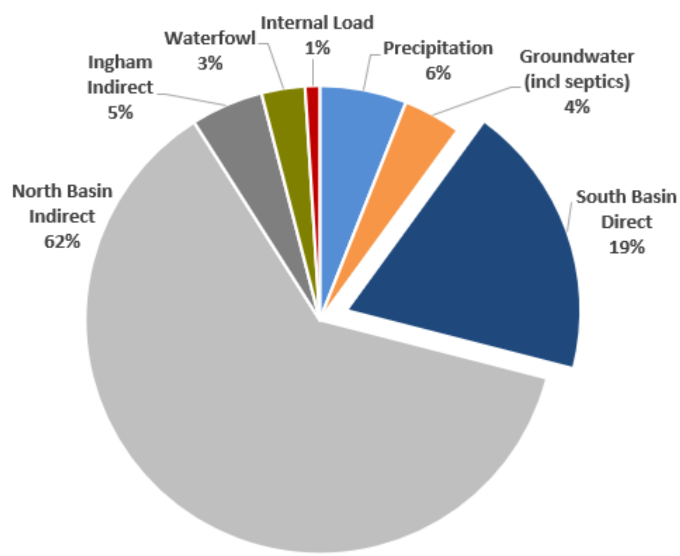
→ Decrease in total phosphorus in the south basin

What are the primary sources of P?

A watershed modeling update was completed using recent monitoring data to estimate current sources of P from the direct and indirect watersheds of Long Pond. The revised model estimates a total P load of 1,463 kg to the north basin, and 1,560 kg to the south basin of Long Pond annually. P load from the indirect watersheds of Long Pond is the dominant source of P in both basins, with Great Pond accounting for 59% of the P load to the north basin (below left). In the south basin, the indirect load from the north basin is the dominant source of P at 62% of the load (bottom right).



P Sources (north basin)



P Sources (south basin)

Why do we need to address NPS pollution?

Nonpoint source (NPS) pollution stemming from residential development, including both shoreline and non-shoreline development, and the roads, driveways, and septic systems that serve them, are considered the most significant threat to the water quality of Long Pond. Stormwater runoff from other land-use impacts such as agriculture and forestry adds to the amount of P getting to the lake. Combined, these sources of P have resulted in a long-term decline in water clarity.

Driveway erosion can result in significant delivery of nutrients and sediments to Long Pond.

The 2020 watershed survey identified **148 sites across the watershed that are contributing P in stormwater runoff**. The greatest number of sites (42%) were documented on residential properties along the shoreline (63 sites), with the majority of sites located in the north basin, and numerous other sites outside the immediate shoreline documented along state/town roads. Roads and driveways accounted for 41% of all sites. The survey reconfirmed previous studies indicating **a lack of effective shoreline buffers on a significant number of residential properties on Long Pond**.

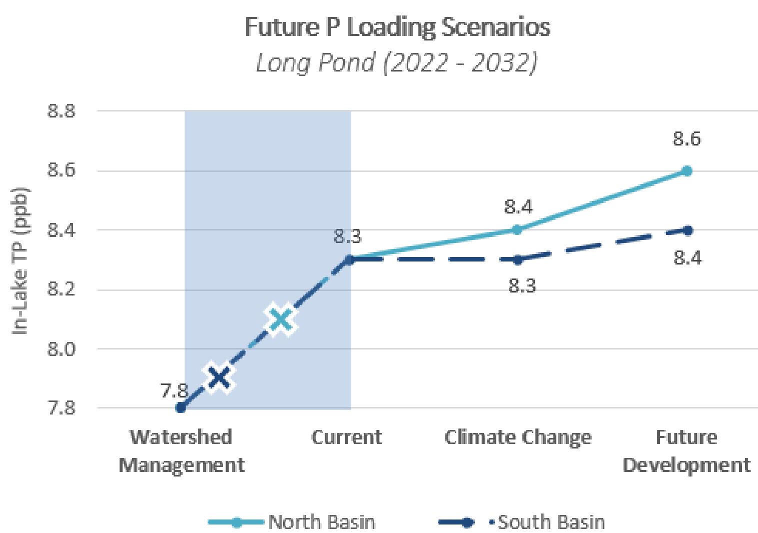
The action plan includes addressing 16 high-impact NPS sites, 61 medium-impact NPS sites, and 71 low-impact NPS sites over the next 10 years, along with an estimated 160 sites that have not yet been documented. The plan also targets **reducing the P load from agricultural land by 25% and taking steps to assess and mitigate impacts of septic systems** - specifically the 81 parcels likely to have a septic system on sensitive soils within the shoreland zone of Long Pond that could result in short-circuiting of the leach field and may be contributing excess P to the lake via groundwater.

Site-specific actions to infiltrate and treat stormwater runoff throughout the watershed will reduce P loading from developed areas. A well-buffered shoreline that mimics natural conditions and consists of a mix of trees, shrubs, groundcovers, and duff to filter and absorb runoff from development will result in less P reaching the lake. Therefore, it is important that every property owner do their part to prevent runoff.

What about future development & climate change?

The watershed contains close to 8,000 acres of buildable area with the largest buildable areas in the towns of Rome (41%) and Mount Vernon (32%). Mount Vernon experienced the greatest increase in population among the five watershed towns between 2010 – 2020 (4%), almost three times the growth rate for Kennebec County, and close to twice the statewide growth rate.

Conservatively, future development in the watershed was estimated to result in an **increase of 18 – 25 kg P/yr in the north basin and 16 - 25 kg P/yr in the south basin** over the next decade. This reflects a minor increase in the in-lake P concentration (0.2 ppb north basin and 0.1 ppb south basin).



The major effects of climate change on the Northeastern US are increasing temperatures and heavier, but less frequent precipitation events. Overall precipitation is increasing, with much of that increase coming from higher intensity storms. The estimated increase in P loading caused by climate change in the Long Pond watershed is **28 – 139 kg P/yr in the north basin and 31 – 153 kg P/yr in the south basin.** This reflects a minor increase in the in-lake P concentration in the north basin (0.1 ppb) based on a 10% increase in precipitation. Cumulatively, future development and climate change are estimated to increase the concentration of P in the lake by 0.3 ppb in the north basin and 0.1 ppb in the south basin (see figure above right). Taking immediate steps now to adapt to climate change and prevent new sources of P for all new development will benefit water quality now and in the future.

ADMINISTERING THE PLAN

The Long Pond WBMP provides a framework for improving water quality trends and preventing further declines in water quality in Long Pond so that the lake meets state water quality standards. The plan will be led by 7 Lakes Alliance with guidance and support from a watershed steering committee comprised of BLA, Colby College, the towns of Belgrade, Rome, and Mount Vernon, Maine DEP, local businesses, and landowners. The formation of subcommittees that focus on the five main watershed action categories will result in more efficient implementation of the plan. The steering committee will need to communicate regularly, especially during the first 1-3 years to get the plan off on solid footing.

INCORPORATING US EPA'S 9 ELEMENTS

The US EPA has identified nine key elements that are critical for achieving improvements in water quality. An approved nine-element plan is a prerequisite for future federally funded work in impaired watersheds. The nine elements are designed to provide a robust framework by which to restore waters impaired by NPS pollution through characterization of the watershed, partnership building, development of an implementation plan (actions, schedule, costs), goal setting, and monitoring. The nine elements can be found in the following locations within the Long Pond WBMP.

Planning Element	WBMP Section	Description
a) Identify Causes & Sources	Section 1	Highlights current programs and research that have helped frame the water quality problem.
	Section 2	Describes the characteristics of the lake and watershed that contribute to the changes in water quality.
	Section 3	Provides an analysis of water quality data to describe changes in water quality.
	Section 4	Provides an estimate of watershed loading including current and future sources of NPS pollution.
	Section 7 & Appx. A	Summarizes NPS sites in the Long Pond watershed.
b) Estimated P Load Reductions expected from Planned Management Measures	Sections 4 & 6	Provides an overview of water quality and phosphorus (P) reduction targets to reduce annual P loading to Long Pond from the direct and indirect watersheds over the next ten years and methods used to estimate P reductions.
c) Description of Management Measures	Sections 6, 7 and 8	Identifies ways to achieve the estimated P load reduction and reach water quality targets described in (g) below. The action plan covers five major topic areas that focus on NPS pollution, including: mitigating the direct and indirect P load, preventing new sources of P, education and outreach, building local capacity, and conducting long-term monitoring and assessment.
d) Estimate of Technical and Financial Assistance	Sections 7 - 10	Provides a description of the associated costs, sources of funding, and organizations responsible for plan implementation. The estimated cost to address NPS pollution and reduce P loading to Long Pond is estimated at $1,656,700 over the next ten years.
e) Information & Education & Outreach	Section 7	Describes how the education and outreach component of the plan should be implemented to enhance public understanding of the project. This includes leadership from watershed partners to promote lake/watershed stewardship.
f) Schedule for Addressing the NPS Management Measures	Sections 7 & 8	Provides a list of strategies and a set schedule that defines the timeline for each action. The schedule should be reviewed and adjusted by the steering committee on an annual basis.
g) Description of Interim Measurable Milestones	Section 9 (Tables 15 & 16)	Lists milestones that measure implementation success that will be tracked annually, makes the plan relevant, and helps promote implementation of action items. The milestones are broken down into two different categories: programmatic and social.
h) Set of criteria	Section 9 (Table 14)	Provides a list of criteria and benchmarks for determining whether load reductions are being achieved over time, and if substantial progress is being made towards water quality objectives. Environmental milestones are a direct measure of environmental conditions, such as improvement in water clarity. These benchmarks will help determine whether this plan needs to be revised.
i) Monitoring Component	Section 8	Provides a description of planned monitoring activities for Long Pond, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (h) above.

1. Background

Long Pond, located in Mount Vernon, Rome, and Belgrade, Maine (Figure 1) has experienced small, incremental changes in water quality beginning around 1990. This included a slow decline in water clarity (1 m over 30 years), a decrease in dissolved oxygen in deep areas of the lake, and the presence of algae in shallow areas of the lake where it hadn't been documented before. In 2006, Long Pond was added to the Maine DEP list of impaired lakes due to declining water clarity and an increase in total phosphorus over the previous 10 years. In 2008, US EPA approved a Total Maximum Daily Load (TMDL) report for Long Pond which examined sources of phosphorus (P) in the lake and included an assessment of upstream Great Pond (Maine DEP, 2008). The TMDL determined that P inputs from Great Pond represented a major source of the total P getting into Long Pond, with Great Pond and its watershed contributing 53% of the P load to the north basin of Long Pond.

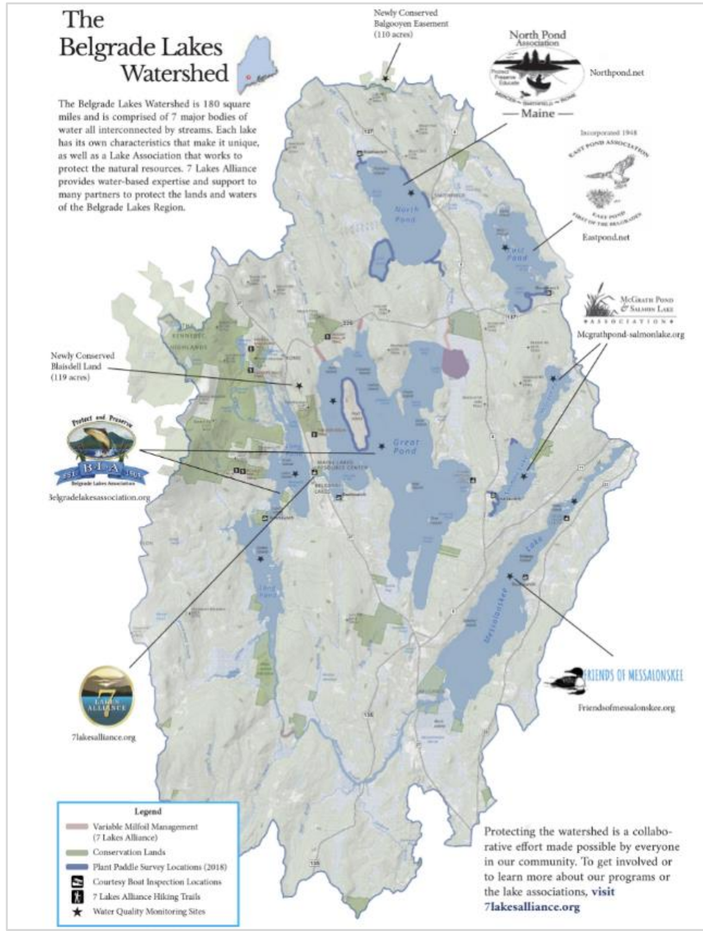


Figure 1. *Belgrade Lakes watershed. (Source: 7 Lakes)*

Other Belgrade Lakes WQ Listing Status and Relationship to Long Pond

East Pond	Impaired. Alum treatment in 2018; likely to be moved to Watch List in 2024	Indirect watershed of Great Pond; flows to North Pond via Serpentine Wetland
North Pond	NPS Priority List, Threatened: Development threat; Watch list due to recent algal blooms and likely on impaired list in 2024	Indirect watershed of Great Pond; flows to Great Pond via Great Meadow Stream
McGrath Pond	NPS Priority List:, Threatened Sensitive	Indirect watershed of Great Pond; flows to Salmon Lake
Salmon Lake	NPS Priority List, Threatened: Watch List; Sensitive (sediment chemistry)	Indirect watershed of Great Pond; flows to Great Pond via Salmon Lake outlet stream
Great Pond	Impaired: Total Phosphorus	Indirect watershed; flows to Long Pond
Messalonskee Lake	NPS Priority List, Threatened: Watch list; Sensitive (sediment chemistry)	Downstream of Long Pond; receives water from Long Pond via Belgrade Stream

In addition to all seven Belgrade Lakes being listed on the State's NPS Priority watersheds list as threatened or impaired, Long Pond and the six other lakes in the Belgrade Lakes chain are also listed as "Most at Risk from New Development" under Chapter 502 of the Maine Stormwater Law. The influence of the water quality in upstream lakes means that activities to prevent P inputs in the upstream watersheds has potential to help stabilize water quality in Long Pond. Consequentially, any increases in P in upstream lakes also has the potential to contribute to further decline in water quality in Long Pond.

In 2008, Maine DEP granted a subaward of US EPA Clean Water Act (CWA) section 604(b) funds to Kennebec County Soil & Water Conservation District (KCSWCD) and the Belgrade Regional Conservation Alliance (BRCA, now 7 Lakes Alliance) to develop a Watershed-Based Management Plan (WBMP) for Long Pond. Recognizing the complex relationship between water quality in Long Pond and Great Pond, the 2009 plan included recommendations and management strategies for the watersheds of both Long and Great Pond.

Since 2009, watershed stakeholders, led by 7 Lakes Alliance (7 Lakes), have invested more than $732,000 in erosion control projects in the watersheds of Long Pond and Great Pond through US EPA Clean Water Act 319 funding to address nonpoint source (NPS) pollution, and another $500,000 in Youth Conservation Corps erosion control projects, among other programs to raise public awareness and reduce P in the lake. More recently, a locally funded watershed survey was conducted to identify high priority NPS pollution sites in the watershed in order to reduce P loading to Long Pond. The survey identified 148 NPS sites that are contributing to the current load of P in Long Pond, making it clear that more work is needed to protect and improve the water quality of Long Pond.

Development of the Long Pond WBMP included a water quality trend analysis utilizing the most current data available, watershed modeling including an internal loading analysis, a septic vulnerability analysis, development of updated watershed maps, multiple steering committee meetings to review and revise the 2009 action plan, and a public meeting to inform the community about the state of water quality in the Long Pond watershed and current actions needed to improve water quality over the next 10 years. Since P is the nutrient driving declining water quality trends in Long Pond, it was used as the primary parameter for setting the water quality goal for the 2022 WBMP.

PURPOSE

The 2022 Long Pond WBMP provides details about current water quality conditions, watershed characteristics, and steps that can be taken to restore water quality in Long Pond over the next 10 years. The update supersedes the previous WBMP developed by KCSWCD in 2009. The plan is estimated to cost $1.66 million to complete through state, federal and local contributions over this time period. The plan outlines management strategies and an activity schedule (2022 – 2032), establishes water quality goals and objectives, and describes actions needed to achieve these goals. This includes strategies to:

1. **Reduce the external phosphorus load** by addressing existing nonpoint source (NPS) pollution in the direct watershed of Long Pond and the indirect watershed of Great Pond;
2. **Prevent new sources** of NPS pollution from getting into Long Pond by addressing new NPS sites, through land conservation, and through municipal ordinances and enforcement that address existing and future development and climate change adaptation;
3. **Raise public awareness** about lake restoration strategies by increasing local education, outreach, and communication efforts to increase participation among municipalities and watershed residents;
4. **Build local capacity** through partnership building across multiple community groups, engaging steering committee members, and developing a robust fundraising strategy;
5. **Monitor and assess improvements** in Long Pond's water quality over time. This includes annual baseline monitoring, documenting changes in internal loading, assessing the current state of septic systems, tracking NPS pollution, conducting stream monitoring, and monitoring for invasive aquatic plants.

STATEMENT OF GOAL

The goal of this plan is to improve water quality trends in Long Pond by reducing phosphorus inputs to the lake from the direct and indirect watersheds. Accounting for current and future phosphorus inputs, planning recommendations include reducing the watershed phosphorus load by 124 kg/yr (86 kg/yr north basin, 38 kg/yr south basin)[5] thereby reducing the average annual in-lake phosphorus concentration by 0.3 ppb in the north basin, and 0.4 ppb in the south basin over the next 10 years. These goals cannot be achieved without reducing phosphorus inputs from the indirect watershed of Great Pond.

WATERSHED PLANNING GOALS

(2022-2032)

1. **REDUCTION IN PHOSPHORUS INPUTS FROM DEVELOPED LAND IN THE DIRECT & INDIRECT WATERSHEDS OF LONG POND**
2. **STABLE OR IMPROVING WATER QUALITY TRENDS**

PLAN DEVELOPMENT & COMMUNITY PARTICIPATION

The 2022 Long Pond WBMP update was developed with input from a diverse group of local stakeholders and scientists over several months. Recommendations are the result of multiple steering committee meetings and numerous subcommittee meetings (including action plan, outreach, and

[5] An additional 60 kg P/yr reduction of the indirect load in the south basin (from the north basin) is not included in this total. The P reduction from the north basin to the south basin is the result of P reductions from watershed management in the watersheds of upstream Great Pond and the direct watershed of the north basin.

water quality review committees). The plan update was led by 7 Lakes in partnership with BLA, the towns of Belgrade, Mount Vernon, and Rome, Maine DEP, and Colby College. Technical support was provided by Ecological Instincts and Water Resource Services.

An interactive online public meeting was held on March 10, 2022 to present the Long Pond WBMP. The meeting, viewed by more than 60 attendees and by others who have viewed the recorded presentation online, highlighted the current water quality trends and presented recommended actions needed to improve water quality. Panelists outlined actions needed to prevent untreated stormwater runoff (and associated phosphorus) from getting into the lake. A link to the recording from the public meeting was posted to the BLA website.

WATERSHED PROJECTS, PROGRAMS & RESEARCH

Long Pond is at the center of ongoing scientific research and monitoring as a result of many years of private/public partnerships involving numerous watershed partners effectively working together to document and understand the changes in Long Pond's water quality and identify the best ways to protect it. The list of projects below represents recent relevant watershed activities. Development of a comprehensive list of projects and an accessible database will be created to track activities conducted by the numerous project partners who work in the watershed.

PLANNING/RESEARCH

(2008) Long Pond Phosphorus Control Action Plan and Total Maximum Daily Load (PCAP-TMDL) Report- Simply stated, the TMDL is the total amount of phosphorus that a lake can receive without harming water quality. Colby College Environmental Assessment Team (CEAT) in collaboration with Maine DEP conducted a comprehensive land use inventory to determine then-current levels of P loading from the Long Pond watershed. Watershed assessment work was also carried out to identify effective phosphorus reduction techniques for the Long Pond watershed. The results of this assessment included recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Long Pond. This project was funded by the US EPA and carried out by Maine DEP, CEAT, and FB Environmental.

(2009) Long Pond Watershed-Based Management Plan- Kennebec County Soil & Water Conservation District (KCSWCD) in cooperation with BRCA developed a management plan for Long Pond which called for 45% reduction in phosphorus to restore water quality. This included a reduction of phosphorus from upstream/indirect watersheds including Great Pond - which accounted for 53% of the total phosphorus load to the north basin of Long Pond. The plan recommended a 17% reduction (278 kg) in annual phosphorus loading from Great Pond to restore water quality in Long Pond. However, these recommendations did not identify water quality goals for Great Pond, only the needed reductions to meet loading reduction targets in Long Pond. The project was funded by a Clean Water Act Section 604(b) grant from EPA.

(2010-2014) Belgrade Lakes Watershed Sustainability Project- An interdisciplinary team of Colby College scientists and local stakeholders worked together over a 5-year period to understand the impact of landscape and lake-ecosystem changes in the Belgrade Lakes region. The project resulted in multiple reports and documents related to the watershed.

(2016) Phosphorus Loading and Related Lake Management Considerations for Long Pond- Water Resource Services reviewed available sources of data to bracket likely loads of phosphorus from identifiable sources and to determine how these affect Long Pond. The fundamental conclusion was that P concentrations in Long Pond were largely a function of watershed loading, with the north basin most impacted by inputs from Great Pond and the south basin most impacted by flow from the north basin. The report stressed the need for a combination of management strategies that address both external and internal loading to achieve desired water quality improvements and indicates that Long Pond would benefit from management in the Great Pond watershed aimed at NPS pollution and consideration of treatment of targeted inflows with aluminum.

(2020) Long Pond Watershed Survey- The BLA led a locally funded watershed survey in September 2020 in collaboration with 7 Lakes, KCSWCD, watershed towns, Maine DEP, and Ecological Instincts. The survey documented a total of 148 different NPS pollution sites around the watershed that affect the water quality of Long Pond. Sites were prioritized by a steering committee, and follow-up letters were mailed to landowners having an identified site with incentives for completing recommendations.

CLEAN WATER ACT SECTION 319 FUNDS

Since 2009, four CWA Section 319 implementation grants (Phase I, II, III, and IV) have supported town and private camp road construction projects in the Long Pond and Great Pond watersheds. Under these grants, a total of 159 BMPs were installed, including 88 BMPs on Long Pond. Pollutant Controlled Reports documented a reduction of 401 lbs. of P loading annually, including an estimated reduction of 213 lbs. of P to Long Pond.[6]

LAKESMART AND YCC

7 Lakes Youth Conservation Corps (YCC) was founded in 1996 to help preserve and improve the water quality in the Belgrade Lakes by addressing erosion and other stormwater runoff issues on residential properties throughout the watershed. Today, the YCC is comprised of two five-person crews, two crew leaders and a field supervisor. Crew members are typically comprised of local high school and college students. YCC is funded by the towns, landowners, private donations, lake associations, and federal 319 grants.

[6] Long Pond Watershed NPS Restoration Project Phase I (2009RT07), Phase II (2011RT07), Phase III (2014RT06), and Phase VI (2016RT05) final project reports, provided by C. Baeder, 7 Lakes Alliance. Pollutant load reduction estimates for past 319 projects were calculated differently from the estimated load reductions in this plan. The current plan uses more conservative P reduction estimates.

To date, YCC has completed 1,693 erosion control projects including 335 on Long Pond. YCC provides a free assessment of residential properties for erosion control including an estimate for potential work, assistance with choosing native plants and ordering project materials, and discounted labor for installing erosion control projects. Types of erosion control projects that YCC has completed include rain gardens; infiltration trenches and drywells for roof driplines; buffer plantings; riprap to stabilize the lakeshore; infiltration steps, ditches and culverts; and water-diverting tools for roads and driveways. The YCC will continue to work with residential property owners throughout the Long Pond watershed.

LAND CONSERVATION

7 Lakes has conserved 11,200 acres in the Belgrade Lakes, 30 Mile River, and Sandy River watersheds since its founding in 1988, through fee acquisitions or conservation easements, including the 7,600-acre Kennebec Highlands, which is primarily located in the Long Pond direct watershed (Figure 2). A major consideration of 7 Lake's land acquisition strategy is preservation of water quality through protection of steep slopes, headwater streams and wetland corridors. The 7 Lakes Land Conservation Plan has identified important "conservation hubs" that will be the focus of future conservation efforts and will help protect important, large unfragmented habitat blocks that are linked by wildlife corridors along headwater streams. Protecting this land from development will help to reduce future phosphorus loading from these areas. Within the Long Pond watershed, a total of 5,644 acres of land are conserved (24% of the land in the watershed). A majority of these conserved lands are managed by the Maine Bureau of Parks and Lands (3,996 acres), or 7 Lakes (1,374 acres).

PUBLIC OUTREACH

BLA and 7 Lakes are the primary entities conducting public outreach in the watershed. BLA hosts an annual meeting each summer for all interested watershed residents, provides watershed updates on its website, and distributes an annual newsletter each summer. BLA does extensive outreach through their Stop Milfoil Campaign, among other outreach activities. 7 Lakes provides technical assistance to the association and to watershed towns to protect and preserve the natural resources within the watershed. 7 Lakes administers the YCC, the LakeSmart program, the Courtesy Boat Inspection (CBI) program, and provides public lectures and guided nature walks. General and targeted outreach and education activities recommended for the next 10 years are presented in Section 7.

WATER QUALITY MONITORING

Water quality data has been collected by Maine DEP and Lake Stewards of Maine (formerly the Volunteer Lake Monitoring Program), in cooperation with the BLA since 1970. More recent, intensive monitoring has been completed by 7 Lakes and Colby College (2015-2021) which included weekly collection of dissolved oxygen/temperature/pH profiles, water clarity, nutrients, metals, and phytoplankton, as well as sediment sampling. Water quality will be discussed in Section 3.

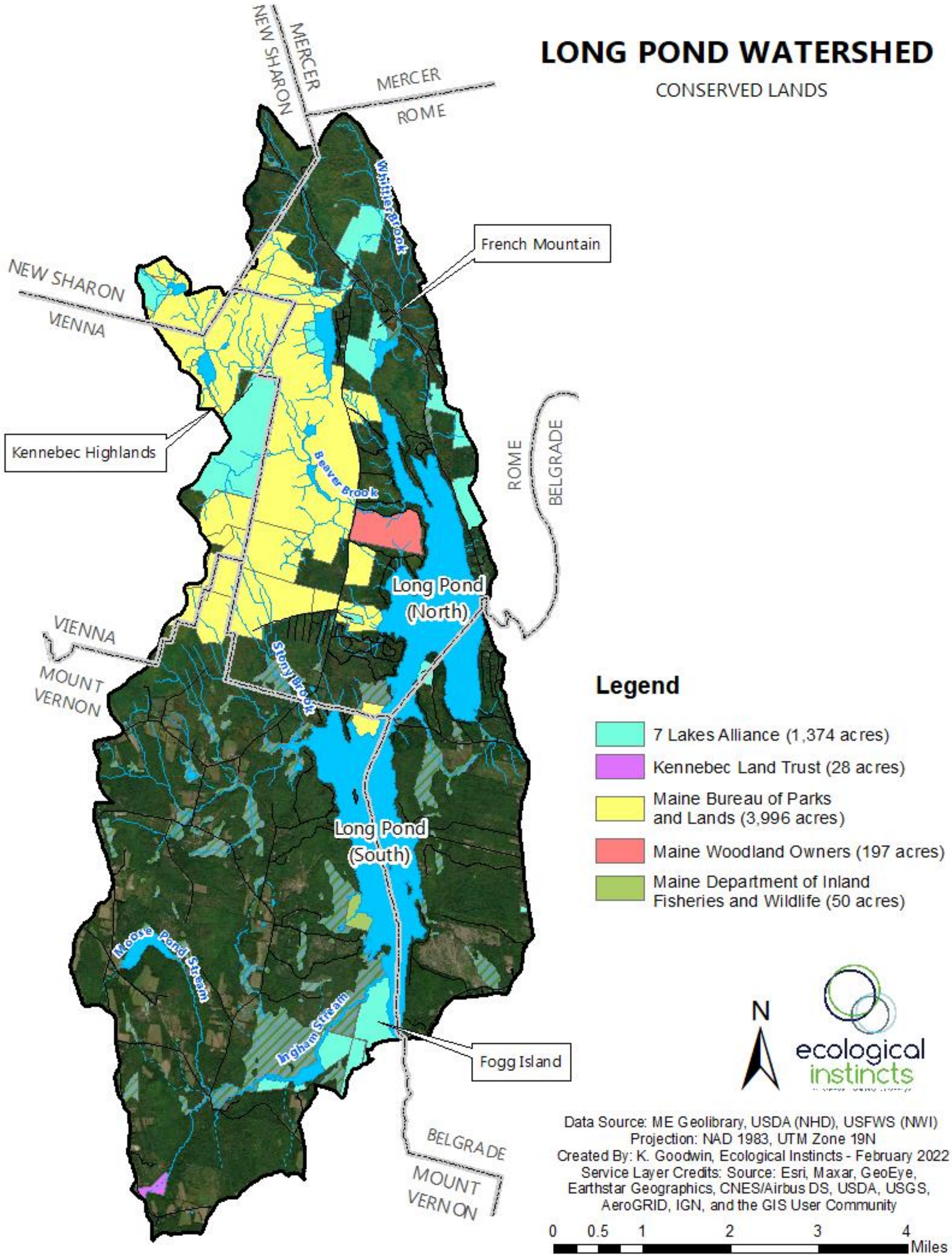


***Figure 2**. Conservation land in the Long Pond watershed.*

2. Lake & Watershed Characteristics

Photo Credit: Alex Wall

Long Pond (MIDAS 5272)[7] is a 2,557-acre lake (Class GPA)[8] located in Kennebec County, in the central Maine towns of Belgrade, Mount Vernon, and Rome (Figure 3). The surface areas of the north and south basin are very similar in size, with the south basin just 6 acres larger than the north basin.

The lake is a naturally formed mesotrophic, dimictic, dual-basin waterbody, with the north basin separated from the south basin by the narrows at Castle Island Rd. in Belgrade. Long Pond is located in the southwest region of the larger Belgrade Lakes watershed and is sixth in the chain of seven Belgrade Lakes. There are five towns in the watershed with Mount Vernon making up the largest land area (44%) followed by Rome (33%), Belgrade (15%), Vienna (6%), and New Sharon (3%). The watershed drains approximately 41 sq mi of the surrounding landscape. The entire watershed area, which includes the indirect watershed of Great Pond to the east, covers 86 square miles. The watershed includes nine other small ponds including McIntire Pond, Kidder Pond, Round Pond, and Beaver Pond which flow into the north basin through Beaver Brook on the northwest shore, and Watson Pond which flows through Whittier Pond at the north end of the lake.

LAKE & WATERSHED FACTS

Watershed Towns:	**Mount Vernon, Rome, Belgrade, Vienna, New Sharon**
Watershed Area:	**40.5 sq. mi.**
Surface Area:	**4 square miles (2,557 acres)**
Max Depth:	**106 ft (32 m)**
Mean Depth:	**25 ft (7.5 m)**
Flushing Rate:	**3.2 /yr. (north basin), 4.9 /yr (south basin)**
Lake Elevation:	**250 ft**
Peak Elevation:	**1,289 ft (McGaffey Mountain)**
Avg. Clarity:	**6.2 m (north basin), 6.0 m (south basin)**
Invasive Plants:	**No known populations**

7 The unique 4-digit code assigned to a lake.

8 Defined by MRSA Title 38 §465-A, Maine Standards for Classification of Lakes and Ponds: Class GPA is the sole classification of Great Ponds (>10 acres) and natural lakes and ponds <10 acres in size.

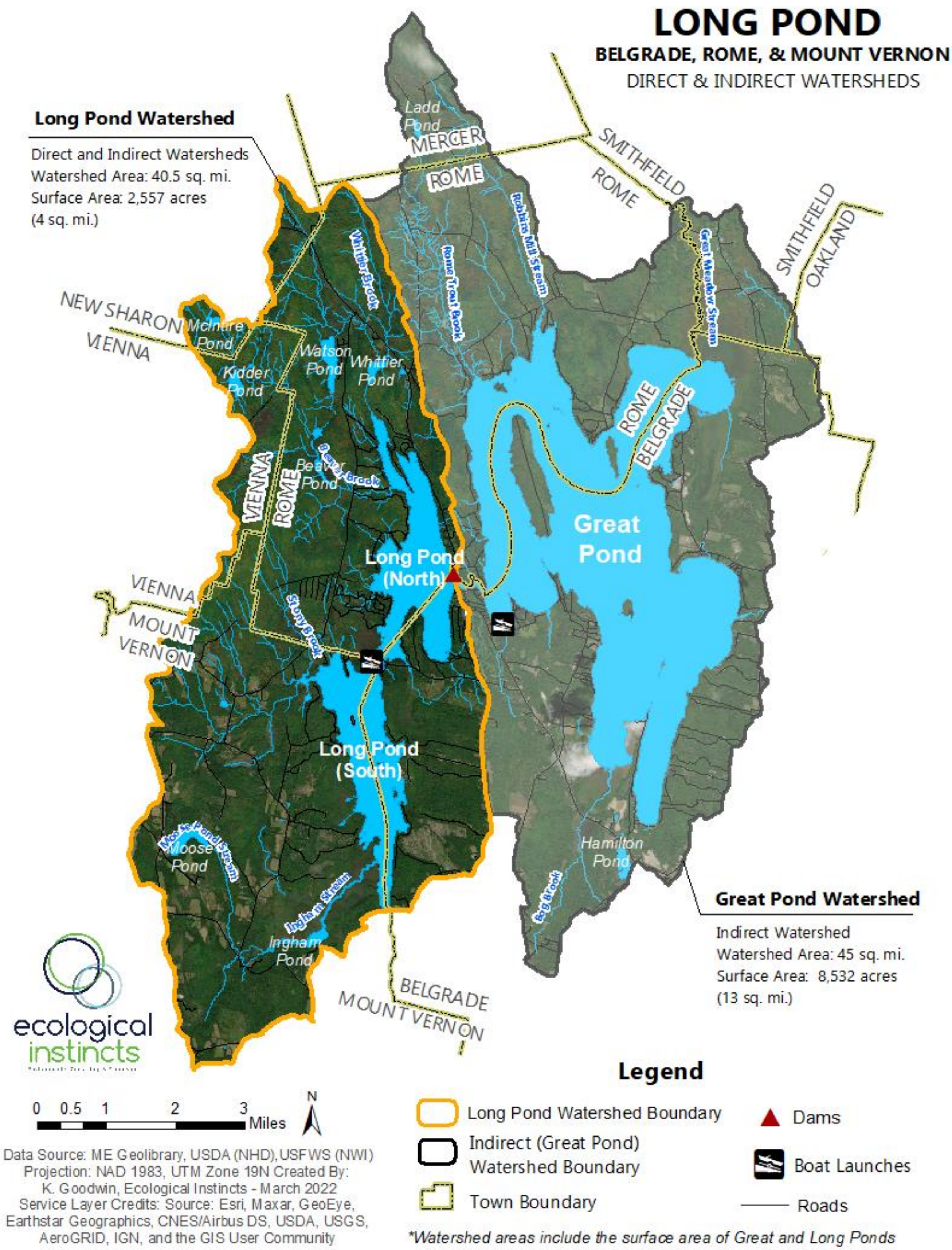


Figure 3. *Direct and indirect watersheds of Long Pond.*

Small ponds in the south basin include Doloff Pond to the west, and Moose Pond which flows to Ingham Pond via Moose Pond Stream, then joins Ingham Stream and its associated wetlands on the south end of the south basin.

The watershed includes 95 miles of streams, 1,943 acres of wetlands, and 3,926 acres of riparian habitat along the edges of lakes, ponds, streams, and wetlands. Approximately 84% of the water that flows into the north basin of Long Pond annually comes from the watersheds of the upstream lakes, with Great Pond accounting for 78% of the water load. Similarly, the annual water load to the south basin is dominated by inflow from upstream waterbodies, with 80% of the water load to the south basin flowing in from the north basin (Figure 4). Long Pond drains into Belgrade Stream which flows over the Wings Mill Dam and downstream to Messalonskee Lake, the last lake in the Belgrade Lakes chain, before draining to the Kennebec River and eventually into the Gulf of Maine.

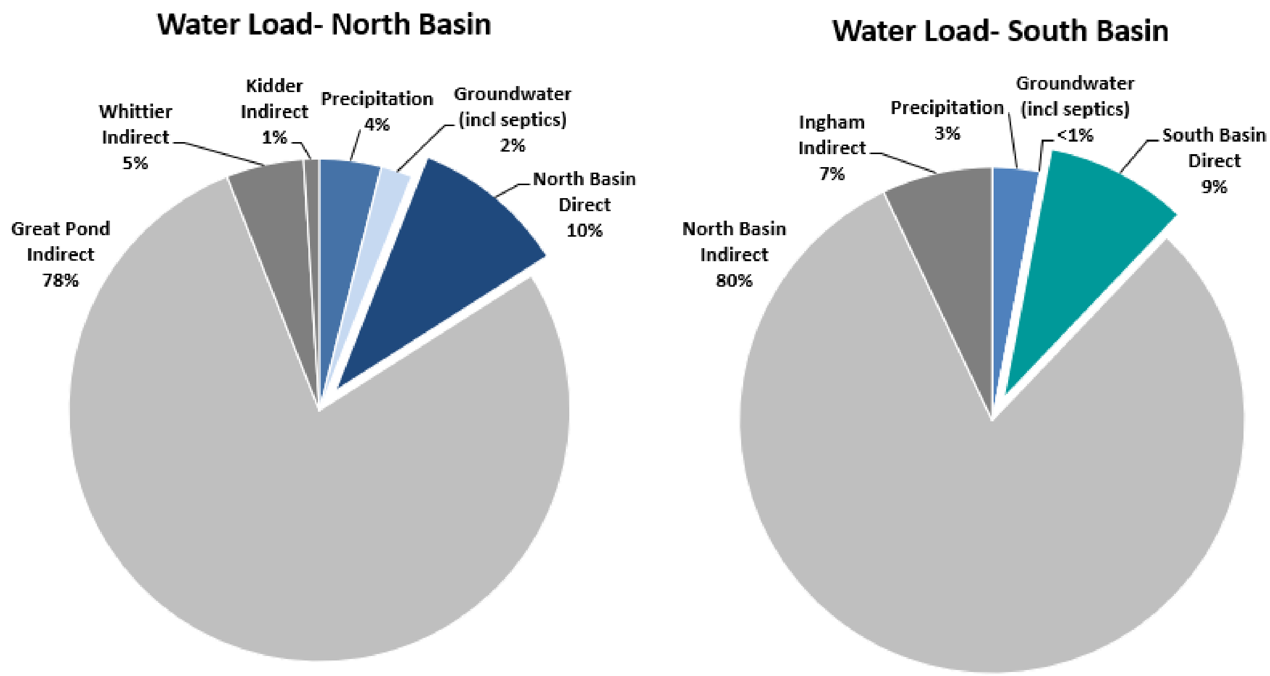


Figure 4. *Water load for the north (left) and south (right) basins of Long Pond.*

The maximum depth of the south basin is 32 m (106 ft). The north basin is shallower, with a maximum depth of 19 m (62 ft). The average depth of of Long Pond is 7.5 m (26 ft). The flushing rate of Long Pond is considered high compared to lakes statewide at 3.2 flushes/yr in the north basin, and 4.9 flushes/yr in the south basin.[9] The elevation of the lake is 250 ft above sea level.The point of highest elevation is 1,289-foot McGaffey Mountain in the northwest corner of the watershed, part of theKennebec Highlands.

A 2007 Colby study reported 393 houses on the shoreline of Long Pond, with 68% on the shoreline of the north basin. In 2009, FB Environmental (2009a) estimated a total of 618 buildings within the

[9] The average flushing rate for lakes in Maine is 1 – 1.5 flushes/yr.

watershed, indicating that the majority of development in the watershed is located along the shoreline. An updated land cover analysis for Long Pond shows that forestland makes up the majority of the watershed (77%). Developed land (e.g., residential, commercial, roads) accounts for approximately 7% of the land area in the watershed, followed by agriculture at 5%. Wetlands and open water (not including the surface area of Long Pond) accounts for the remaining 11% of the watershed area. Land cover varies slightly between the direct drainages of the north and south basins with the north basin containing slightly more forestland (84%) compared to the south basin (71%), and the south basin containing more wetlands and agricultural land (13% and 8%, respectively) compared to the north basin (8% and 1%, respectively).

There are 86 miles of roads (~500 acres) in the watershed, the majority (59%) of which are unpaved gravel roads[10] that service high-density residential development along the shoreline. The remaining 41% of roads are paved, including Augusta Rd. (Rt. 27) and West Rd. that provide access to the eastern shore of Long Pond; Castle Island Rd. that runs east/west between the two basins of Long Pond; Watson Pond Rd. and Bean Rd. that provide access to the Kennebec Highlands and to the western shore of Long Pond; and several other paved roads in the outer watershed areas within all three towns. Commercial development is primarily limited to Belgrade Lakes Village and Rt. 27 as well as Castle Island Camps.

Conservation land is a prominent feature of the watershed, with approximately 24% (5,644 acres) of the watershed permanently protected from development, with the majority of conserved land associated with the Kennebec Highlands in Vienna, New Sharon, Rome, and Mount Vernon.

POPULATION, GROWTH, & MUNICIPAL ORDINANCES

POPULATION

The Belgrade Lakes area provides excellent year-round recreational opportunities and is highly desirable as a summer vacation destination. Long Pond and its surrounding watershed are used extensively for swimming, fishing, and boating as well as bird watching and hiking in the summer, and ice fishing, skiing, snowshoeing, and snowmobiling in the winter. Long Pond is part of the scenic backdrop for Belgrade Village and is visible from the top of the Kennebec Highlands' hiking trails which overlook the watershed.

Major shifts in the local population occur annually with the population of the Town of Belgrade (~3,000) doubling when seasonal residents and vacationers arrive in the summer, and the Town of

[10] The % of gravel vs. paved roads was calculated by Charlie Baeder, 7 Lakes Alliance, February 2022.

Rome's population is estimated to triple or quadruple in the summer.[11] Approximately 1/3 (34%) of all homes in the larger Belgrade Lakes watershed are seasonal.[12] Most of these seasonal homes are shorefront properties. In Belgrade, 86% of all shorefront properties are either seasonal or second homes. Shorefront properties account for 60% of the property tax valuation in Belgrade, 65% in Mount Vernon, and 75% in Rome.[13] This seasonal influx of recreational users is a major contributor to the local economy, providing numerous economic benefits for local businesses and residents. These businesses rely heavily on good water quality to support the tourist economy.

View south on Augusta Rd. (Rt. 27) in Belgrade Lakes Village. (Photo Credit: Alexander Wall, BLA)

Population and demographics are important factors in watershed planning because large increases in unplanned population growth, and consequently development, could negatively affect lake water quality. Conversion of seasonal or second homes to year-round homes would result in a significant change in use of the developed shoreline, increasing the potential for increased stormwater runoff and impacts from septic systems among other factors.

According to the U.S. Census Bureau, the population of Kennebec County in 2020 was 123,642, representing an increase in population by 1.2% since the last census in 2010 (US Census 2018). Kennebec County can be easily accessed by both I-95 from the south, and Route 2 from the east and west. There is limited public transportation in the area, and most people use personal vehicles in their daily commute. Augusta, the closest commercial area, has a commercial passenger service to its airport and receives most goods by truck and limited rail shipment. People living in the area are attracted to the lakes and all they have to offer, the small-town character, and the reasonable commuting distance to Augusta, Waterville, and Farmington. The average Belgrade Lakes Region resident travels between 24 and 27 minutes and 16 to 21 miles to Augusta and Waterville, respectively (Hart and Panning, 2010).

Between 1990 and 2005, the population in the towns of Belgrade, Rome, and Mount Vernon increased by 43%, 40%, and 20%, respectively (SPO, 2008). However, this growth slowed considerably over the past 10 years with the highest growth rate in Mount Vernon (4%), and the lowest in Belgrade which showed a population decline of 1.2% (Table 1).

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[11] Lakes of Maine: www.lakesofmaine.org.

[12] This extends to waterfront camps on the shoreline in the Town of Rome as estimated by Andy Marble, the town's code enforcement officer.

[13] 2012 Statistical Abstract of the Belgrade Lakes Watershed, Colby College; and personal communication, Charlie Baeder, 7 Lakes Alliance, February 6, 2021.

Table 1. *Population demographics for the towns of Belgrade, Mount Vernon, Rome, and Vienna, Kennebec County, and the State of Maine.*

Town	Population		
	2010	2020	% growth
Mount Vernon	1,640	1,706	**4.0%**
Vienna	570	578	**1.4%**
Rome	1,010	1,013	**0.3%**
Belgrade	3,189	3,150	**-1.2%**
Kennebec County	122,151	123,642	**1.2%**
State of Maine	1,328,361	1,362,359	**2.6%**

The exact amount of additional development may vary based on population growth and the amount of land protected as open space, zoning and other regulations, and socioeconomic factors. A build-out analysis completed in 2009 (FBE, 2009a) indicated that there is room for significant additional development in the watershed. This is based on an additional 6,236 acres of buildable area in the watershed (36.4% of the watershed area) (Figure 5), with the largest buildable area in the Town of Mount Vernon (45%) followed by Belgrade (29%), and Rome (22%).[14] The buildout analysis estimated that at an annual 1.1% growth rate, there would be an additional 180 new buildings in the watershed by 2030, and the watershed would be 30% built out by the year 2112 (1,272 new buildings).

The analysis estimated that between 30 and 120 kg/yr of additional phosphorus would be delivered to Long Pond annually under the 30% buildout scenario, depending on the ordinances in place for new development. P estimates for future development were used to help set the water quality goal Long Pond for the next 10 years (2022 – 2032) (Section 4).

Municipal Ordinances

Given the extent of buildable land in the watershed, and the potential increase in P, there is an immediate need to reduce the amount of phosphorus getting to Long Pond from both existing development within the watershed and from future development. As the watershed continues to develop over time, erosion from disturbed areas will deliver new and previously unaccounted for phosphorus into Long Pond, thereby affecting the success of planned management strategies to improve water quality.

Photo Credit: Carol Johnson, BLA.

[14] A little less than 4% of the buildable area is located in Vienna and New Sharon.

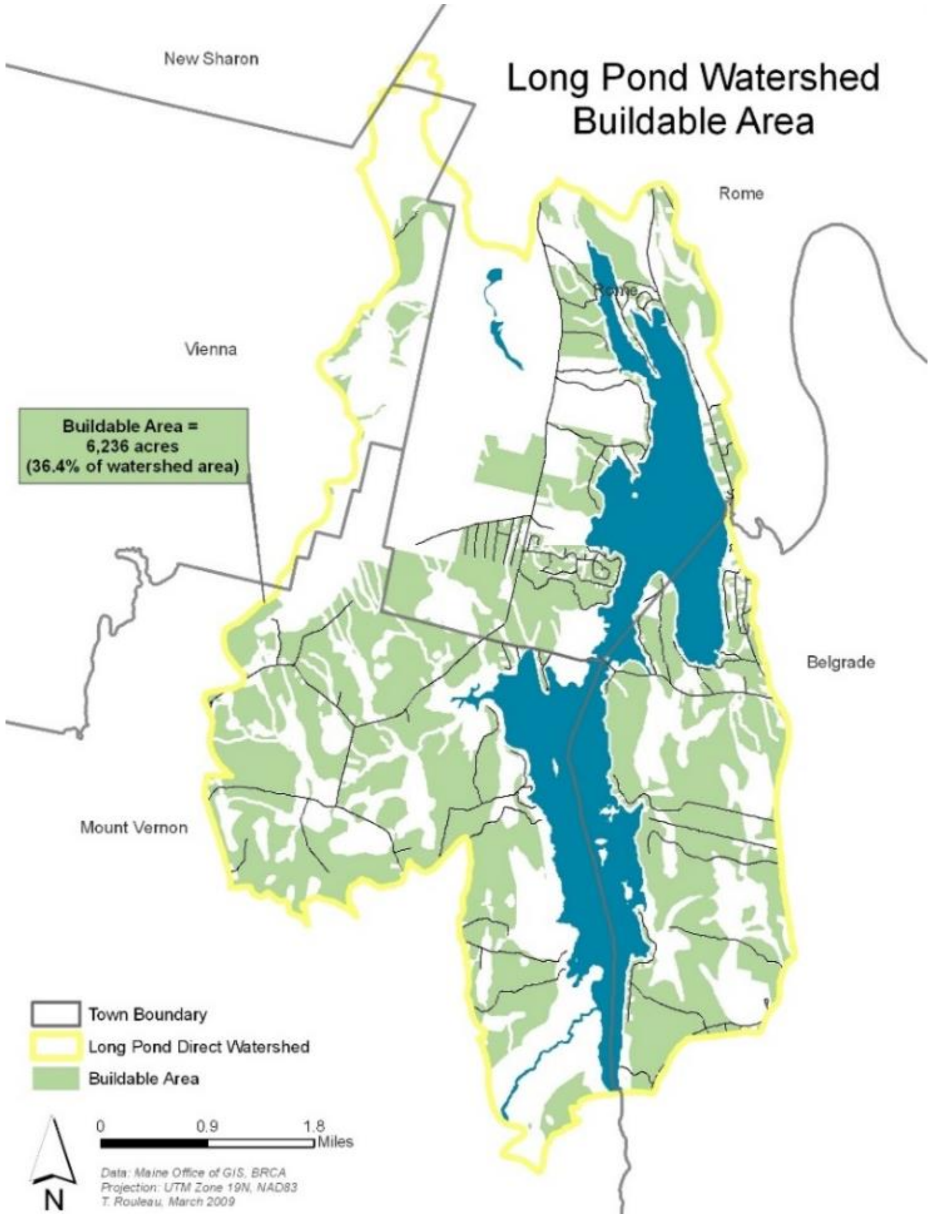

Figure 5. *Buildable area in the Long Pond watershed. (Source: FBE, 2009a)*

A municipal ordinance review was conducted for Belgrade and Rome as part of the 2009 Long Pond WBMP (KCSWCD, 2009). The ordinance review included 22 recommendations for minimizing stormwater runoff and reducing the amount of phosphorus stemming from new residential and commercial development. Towns in the watershed have taken a proactive approach to lake protection since the development of the 2009 WBMP. This includes the following work in the Town of Belgrade:

- **2014**- Belgrade voted to approve the addition of Natural Resources and Water Resources to its new Comprehensive Plan.
- **2020**- Belgrade formed a Lakes Committee to advise the Selectboard on local regulations and actions that will help preserve and protect Belgrade's lakes.

- **November 2020**- a town vote in Belgrade resulted in an approved moratorium on new applications for subdivisions, solar and wind farms, and telecommunications towers to allow the Planning Board time to craft a new subdivision ordinance with amendments to the Commercial Development Review Ordinance (CDRO) to mitigate the impact of stormwater runoff and erosion.
- **2022**- Belgrade will vote on further CDRO amendments that address the impact to lake water quality, specifically phosphorus loads, export standards, and control measures. A Comprehensive Plan Implementation Oversight Committee meets monthly in Belgrade to review progress in adopting recommendations for water quality in the plan.[15]

Similarly, the Town of Rome has been actively updating their ordinances to be more protective of water quality.[16] This includes:

- **2011 – 2020 (Ordinance Updates)-** Over the last ten years, the Town of Rome has adopted several ordinance updates including:
  - Adoption of a Wind Energy Systems ordinance (regulates commercial wind farms).
  - Update and adoption of a more extensive Wireless Telecommunications Ordinance.
  - "Bunkhouse" definition and regulations added to the Shoreland Zoning Ordinance.
  - Septic inspection requirements (mirroring the new state requirements) added to the shoreland zoning ordinance for all transferred properties in the shoreland zone. This also requires inspection reports to be submitted to the town.
- **2022**- In March, residents voted to approve a commercial Solar Moratorium Ordinance that will allow for a solar ordinance to be drafted.
- **2022**- Residents also voted to approve updates to the shoreland zoning ordinance addressing "revegetation requirements" within the shoreland zone.

Continued evaluation of ordinances in all three towns is needed to determine what improvements have been made, and what work is still needed to improve practices that protect water quality. A regional approach may be the most effective at protecting lakes within the larger Belgrade Lakes Watershed since all of the lakes fall within multiple towns.[17] Ultimately, it will be less expensive and more efficient to make smart decisions about how and where development occurs, and to require P controls on all new development now, than to try and retrofit development that was not designed to

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[15] Personal Communication. Anthony Wilson. Email, 2022

[16] Rome has also taken other actions to protect water quality over the past 10 years including approving a 50% increase in hours for the town's CEO, a complete rebuild of Watson Pond Rd., and a clean up of a large junkyard on Rt. 27 (over 700 cars removed) in 2020.

[17] As of this writing, an ordinance review is being conducted for the towns in the North Pond watershed which includes the Town of Rome.

protect water quality. More than 50 Maine communities have adopted P control ordinances for all types of development including lake watersheds at risk from development.

In addition to phosphorus control standards for all new development, long-term strategies such as enforcement of existing shoreland ordinances, and permanent protection of sensitive riparian zones and undeveloped forests, are all important municipal management considerations. A list of municipal planning actions is presented in Section 7.

LAND COVER

Land cover is an important component of watershed modeling and can be used for identifying shifts in land cover types and tracking changes in development within a watershed over time. Unmanaged forests, for example, are natural filters for rainwater and deliver very little phosphorus downstream when it rains compared to more intensive land cover types such as high- and medium-density residential and commercial development, and roads- all of which prevent rainwater from getting absorbed into the ground resulting in increased runoff and delivery of phosphorus and other pollutants to the lake. In the Long Pond watershed, forestland (including recent timber harvesting) dominates the landscape, accounting for 77% of the land in the watershed (Figure 6 & Figure 7).

The watershed of the north basin has a higher percentage of forestland (84%) than the south basin (71%) which may be due to the large area of conserved land in the Kennebec Highlands on the north end of the watershed. However, the south basin has a higher percentage of wetlands and open water (13%), largely due to the Ingham Pond area on the south end of the watershed. The south basin also has more agricultural land (8%) than the north basin (1%) which is primarily hayland in the southwest corner of the watershed in the Town of Mount Vernon (Figure 7). Development is largely focused along major roadways and the the shoreline, with the north basin experiencing more development than the south basin. Roads, including state (Rt. 27), town, and private roads (including numerous gravel roads that provide access the shoreline) encircle the lake. The watershed has experienced several large timber harvests, some of which are reflected in Figure 6, but a more detailed land cover update would be needed to document all recent occurences, and a more robust model than was used for the plan to assess its effects.

The land cover analysis was used to help estimate P load reductions from developed land over the next 10 years based on the relative percentage of P loading from each land cover type (Appendix E).

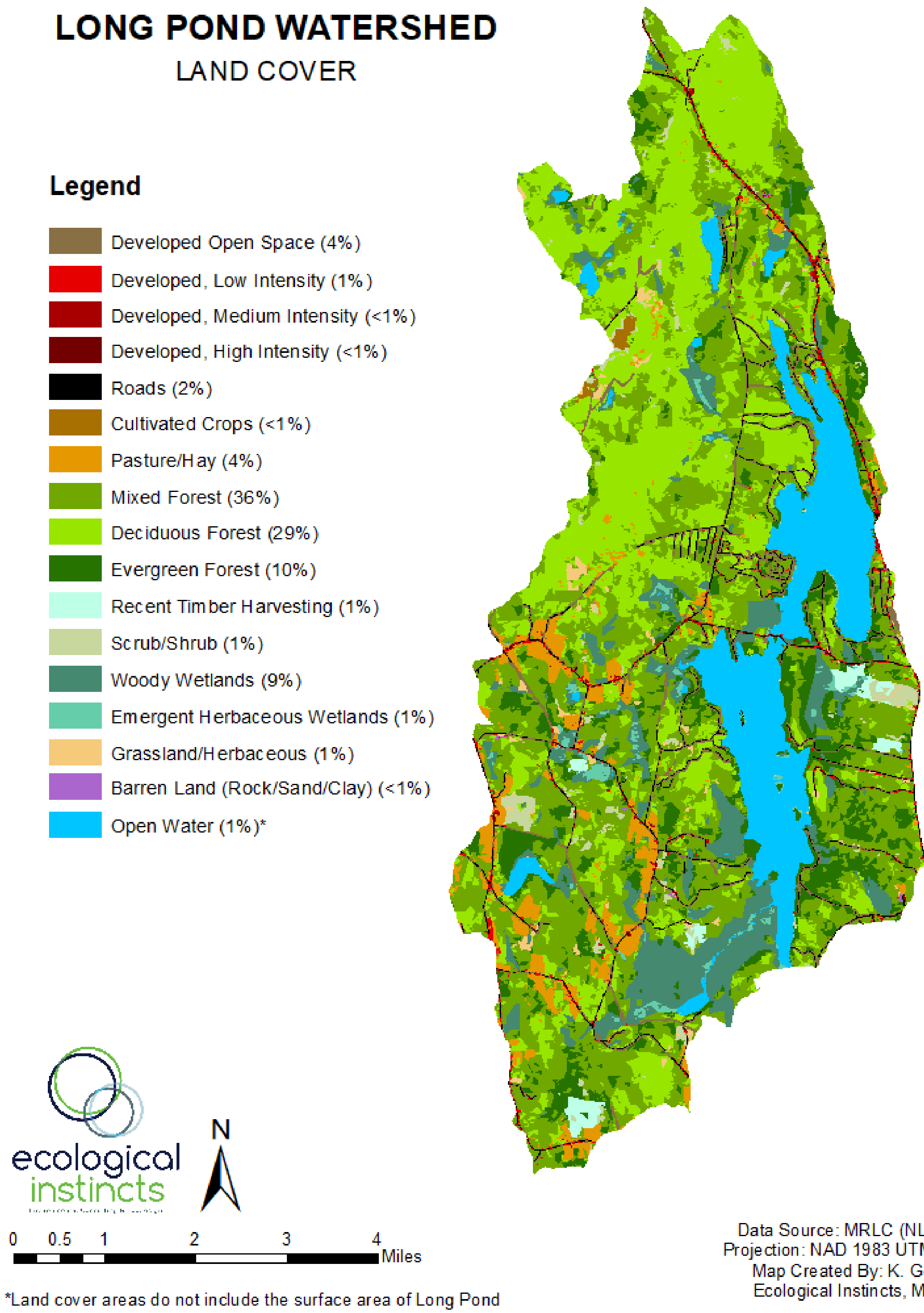


***Figure 6**. Land cover in the Long Pond watershed.*

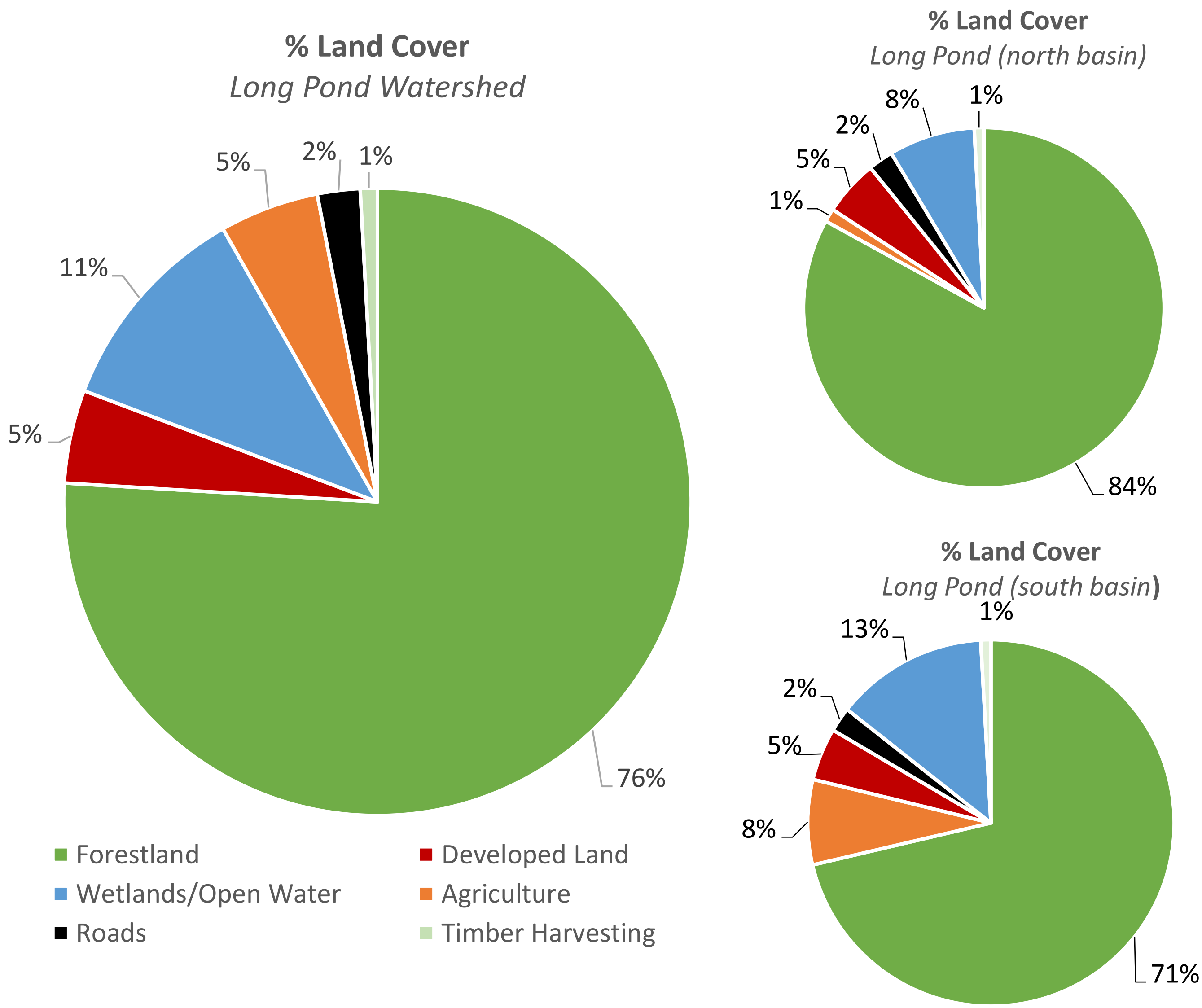


Figure 7. *Land cover by percent cover and by lake basin for the Long Pond watershed.*

SOILS

Factors such as topography, soil type, erosive potential, and land alteration all influence the degree to which soil erosion occurs. The topography of the region consists of rolling hills to the east and low mountains to the west, with elevations of the highest peaks reaching between 500 and 1,200 feet. The steepest slopes (>20%) occur primarily north and west of Long Pond in the Kennebec Highlands and are associated with Round Top and McGaffey Mountain to the west, and The Mountain on the northeast shore.

Soils in the watershed are derived from glacial till, a result of the glaciers that covered Maine more than 12,500 years ago. Soil associations are groups of soils with similar characteristics. The Long Pond watershed is characterized by the Dixfield-Colonel-Lyman-Brayton general soil association which consists of stony, loamy soils formed in glacial till (Ferwerda et. al., 1997). This soil association constitutes 100% of the land area in the direct watershed of the north basin, and over 50% of the direct watershed area of the south basin (DEP 2008a).[18] Soils along the southwestern border of the south basin are typified by the Scantic-Lamoine-Buxton-Lyman general soil association, which consist of clayey and loamy soils formed in glaciomarine or glaciolacustrine sediments and loamy till (Ferwerda et. al., 1997).

The composition of each soil type dictates the amount of phosphorus, iron, and aluminum exported to Long Pond from the watershed soils, and therefore define the composition of sediment that has settled at the bottom of the lake. An analysis of sediments from upstream Great Pond showed that over 80% of the phosphorus, iron, and aluminum that enters the lake through runoff accumulates within the sediment at the lake bottom (King, 2020).

AT-RISK SOILS AND SUBSURFACE WASTEWATER SYSTEMS

Soil type also affects the suitability for infrastructure, specifically for septic systems. Detailed information about the state of septic systems and their potential impact on the water quality does not currently exist for Long Pond. Typically, the first step in targeting pollutants from failing, malfunctioning, or poorly designed systems is to develop a list of all septic systems within the shoreland zone and adjacent to tributaries draining to the lake.

Maine DEP (2022) conducted a septic risk analysis of soils in the Long Pond watershed. Coarse and shallow to bedrock soils along the shoreline of Long Pond (and near tributary streams) are considered "at-risk soils", due to the rapid permeability of these soils that may result in septic system leach field effluent "short-circuiting" to groundwater. Short-circuiting occurs when septic tank effluent is not properly treated in the leach field because the soils are coarse and porous, which allows the effluent to move through them too quickly. Additionally, soils with shallow water tables and shallow-to-bedrock soils that abut or are hydrologically connected to the lake are also considered at-risk due to lack of treatment area where the leach field might rest on fractured bedrock resulting in no treatment of effluent before reaching groundwater which might then flow into the lake.

Soils in the Long Pond watershed that are most susceptible to short-circuiting are presented in orange and red in Figure 8. The 194 parcels located within these soil types are considered a high priority for future subsurface wastewater investigations. At-risk soils encompass 6,140 acres, or about 24% of the watershed area.[19] Most parcels are located on shallow to bedrock soils, as coarse soils make up a very small area within the watershed. Of the five watershed towns, Rome and Mount Vernon contained the most at-risk parcels. Rome contained more parcels directly on Long Pond as well as more parcels likely to contain septic systems within the buffer area than Mount Vernon. The other three towns, Vienna,

[18] The watershed area used for the TMDL included a section of Belgrade Stream from the southern end of the south basin of Long Pond to the Wings Mill Dam. Therefore, watershed areas reported for the soils analysis may be slightly different than was previously reported since an updated soils analysis was not a part of the 2022 WBMP update.
[19] Calculated as 25,935 acres, inclusive of waterbodies.

New Sharon and Belgrade, had less than ten at-risk parcels each and only a handful of these were likely to have septic systems (Table 2). About 42% of the high priority at-risk parcels were likely to contain a septic system in an at-risk soil.

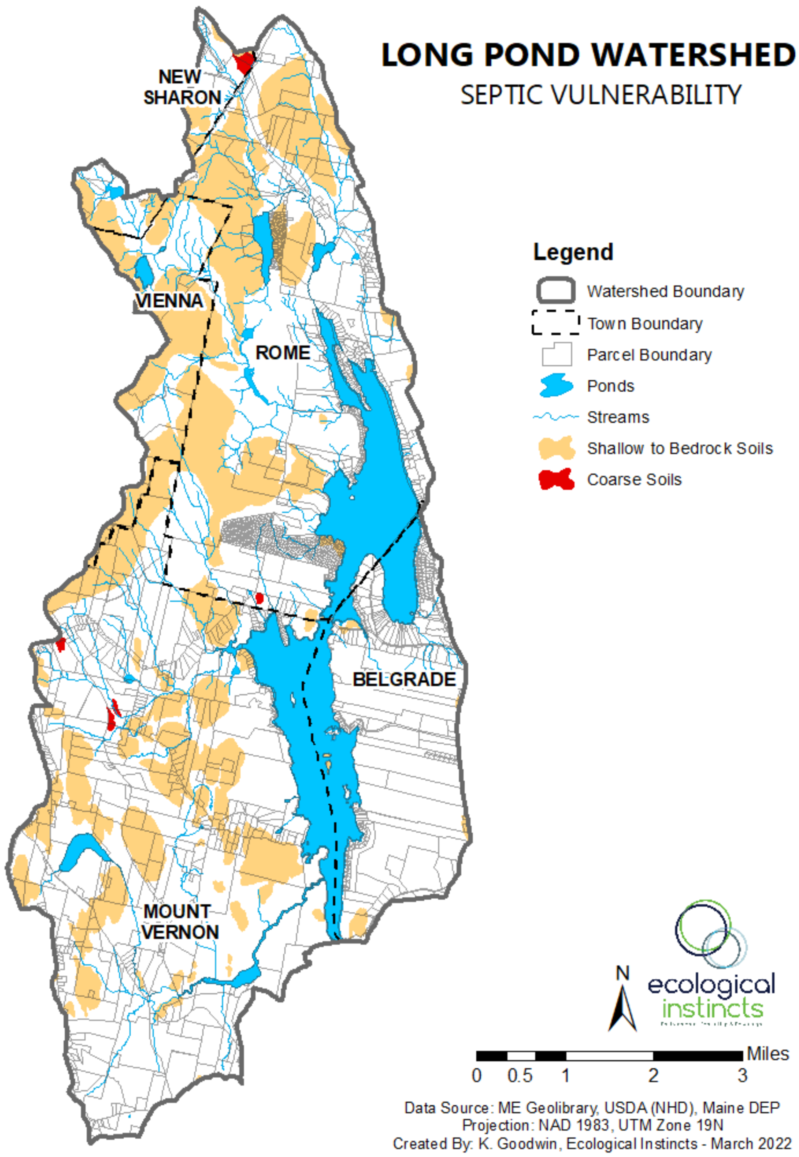


Figure 8*. Long Pond at-risk soils and associated parcels.*

Table 2. *Number of high priority parcels by town that are likely/unlikely to have a septic system within the shoreland zone. (Source: Maine DEP)*

Town	Likely	Unlikely	Total
Rome	58	36	94
Mount Vernon	18	59	77
Vienna	0	9	9
New Sharon	1	6	7
Belgrade	4	3	7
Total	**81**	**113**	**194**

The likelihood that a parcel identified as vulnerable to septic short-circuiting has a septic system located on the parcel and within the shoreland zone (within 250 feet of the shoreline) was determined based on a rapid visual assessment of aerial imagery. For shallow to bedrock soils, likelihood of a septic system was assessed for only the portion of the parcel that intersected with the 150' or 75' buffer within the property. These were counted as likely if the buffer was in or directly adjacent to a building or cleared area near a building. Because the area containing coarse soils was so small, all parcels on these soils were assessed.

Of the soils of concern identified, 99% by area are shallow-to-bedrock and only 1% are considered coarse and at high or very high risk for short circuiting. An assessment of the 12 parcels on coarse soils shows that five parcels are developed with buildings, but none of the developed area is within 75' of a stream or 150' of a pond, therefore, they should be a lower priority for follow up assessment.

A recommendation for future assessment is to focus on the shoreline parcels on at-risk soils with likely septic systems in Rome (30 parcels), Mount Vernon (8 parcels), and Belgrade (4 parcels). Town septic system permit records can be used to identify the location and age of septic systems on these parcels, allowing for further prioritization of parcels for on-the-ground inspection. This is a recommended action item for the watershed plan.

Priority for Septic System Evaluations

Long Pond Watershed

1. Old systems (pre-1974) within the watershed, with priority to systems located on at-risk soils;
2. Systems (pre-1995) located on at-risk soils located within 250 feet of lake; and
3. Systems (pre-1995) located on at-risk soils within 75 feet of any tributary stream and/or wetland draining to Long Pond.

BATHYMETRY

The morphology (shape) and morphometry (measurement of shape) of lakes have been shown to be good predictors of water clarity and lake ecology, where large, deep lakes are typically clearer than small shallow lakes. Bathymetric data is useful for estimating the mass of phosphorus within each basin by depth, for assessing internal loading, and examining changes in the Anoxic Factor in the lake which requires a reliable bathymetric map.

The most recent bathymetric map for Long Pond was created by Colby College (Figure 9).[20] The current area, volume, and mean depth of the north and south basins suggest slightly larger area and volume for the north basin but slightly deeper mean depth for the south basin (Table 3). The maximum depth of the south basin is considerably deeper than that of the north basin, but the volume associated with that extra depth is relatively small (WRS, 2022).

[20] The Colby bathymetry is slightly different than bathymetry from DEP which estimates an average depth of 11 m, compared to 7.5 m from the Colby data. A review of the two data sets is needed to better understand the differences.

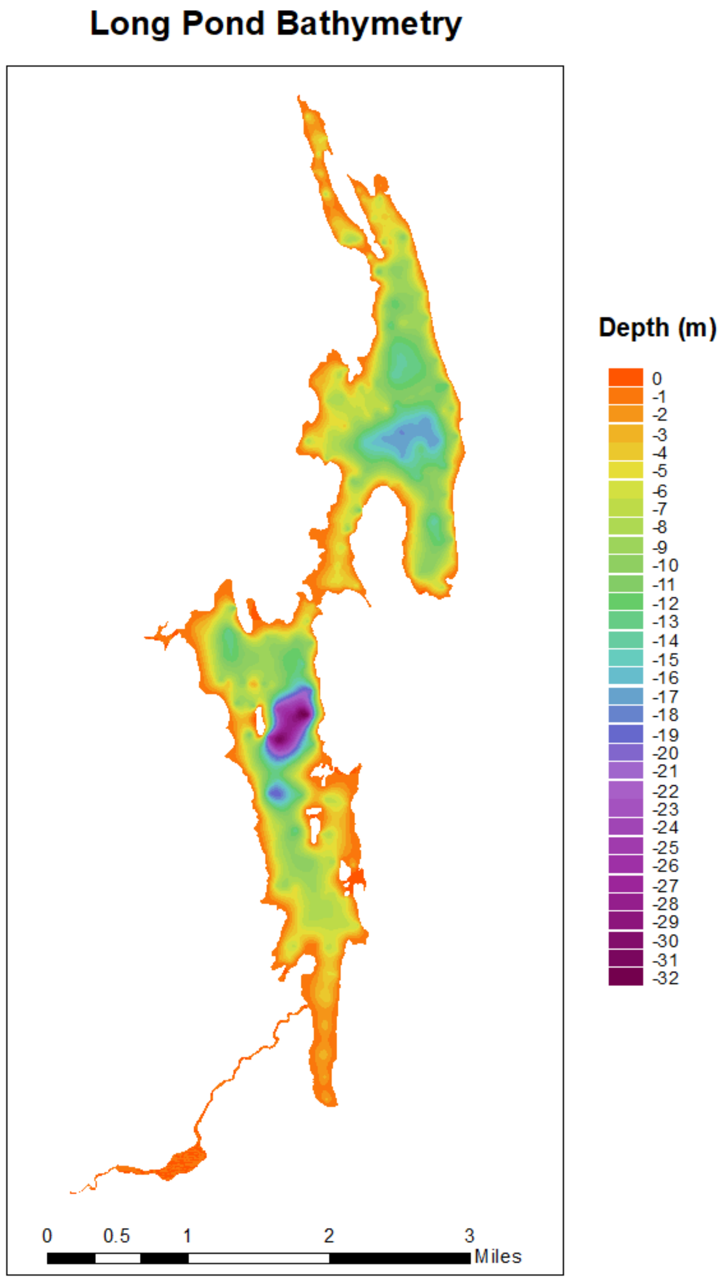


Figure 9. *Bathymetric map for Long Pond. (Source: Colby College)*

Table 3. *Area, volume, and mean depth of Long Pond basins. (Source: WRS, 2022)*

	North Basin	South Basin
Basin Area (million m²)	5.1	4.1
Basin Volume (million m³)	38.3	31.0
Mean depth (m)	7.5	7.6

WATER RESOURCES AND WILDLIFE HABITAT

Wildlife habitat is not limited to Long Pond and its shoreline. Fish and wildlife require suitable upland habitat, with healthy riparian buffers, wetlands, and large undeveloped habitat blocks strategically linked to provide movement of wildlife. An assessment of water resources and habitat was completed for the Long Pond watershed (Figure 10 & Figure 11) using Beginning with Habitat (BwH) data.

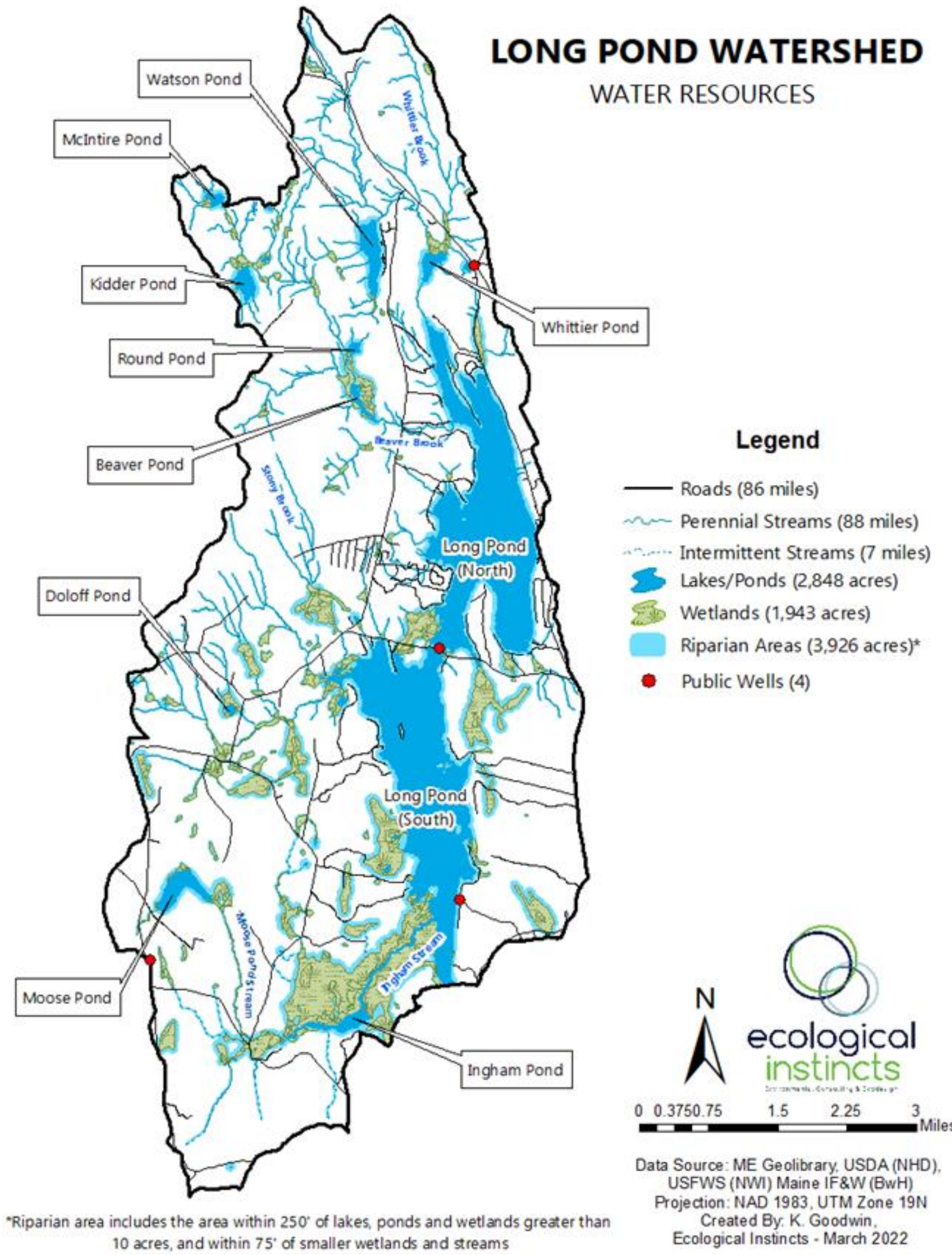


Figure 10. *Water resources in the Long Pond watershed.*

Riparian habitat is the transitional area between aquatic habitats and dry, upland areas.

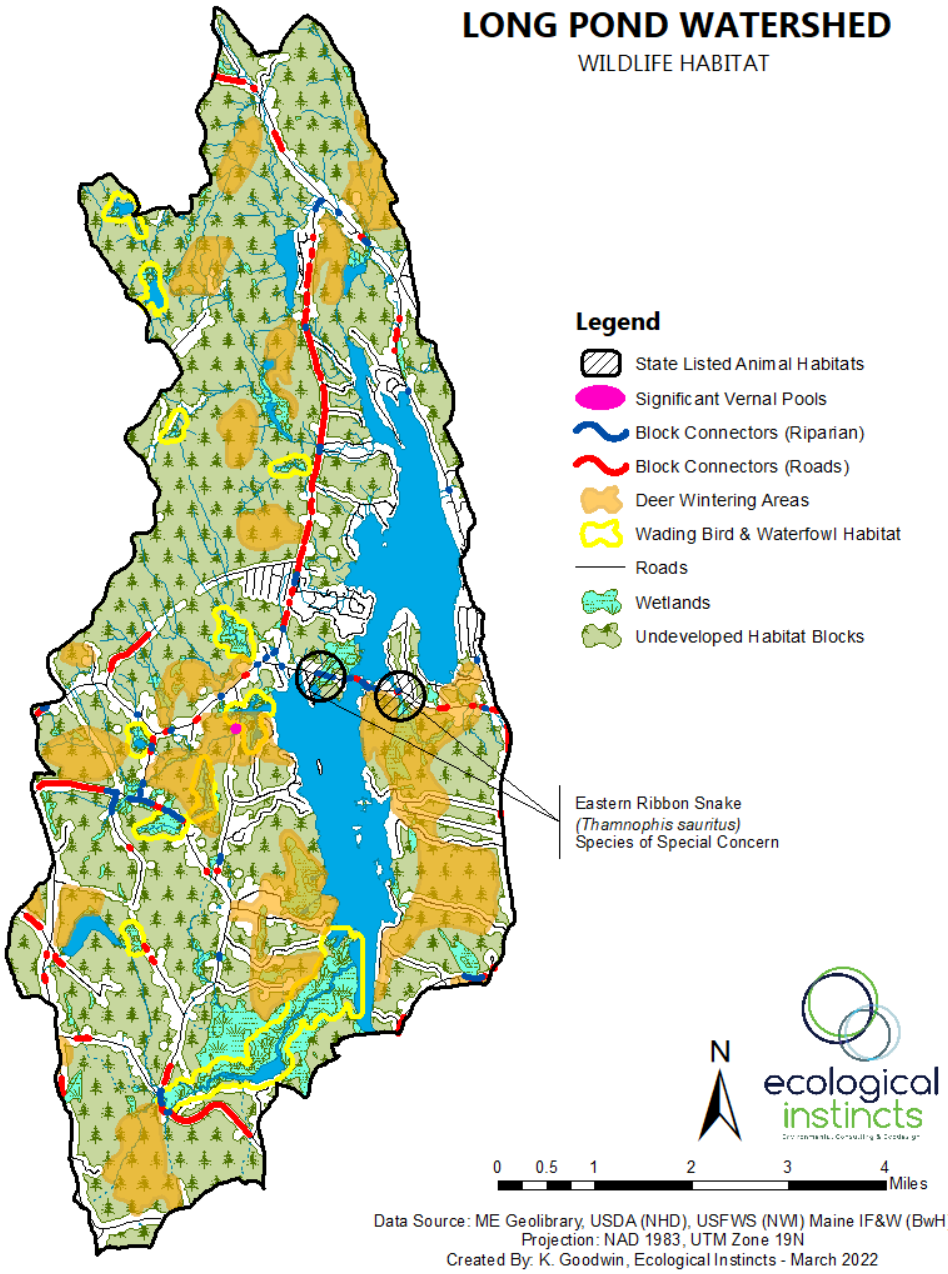


Figure 11. *Wildlife habitat in the Long Pond watershed.*

Results of the assessment highlight the wealth of water resources in the watershed, including 1,943 acres of wetlands, 95 miles of streams, 2,848 acres of open water, and 3,926 acres of riparian habitat. Healthy riparian zones are not only important for water quality but are essential for more than 60 species of Maine wildlife, as more animals live in riparian zones than in any other habitat type in Maine, with hundreds of species depending on riparian zones for survival (ME Audubon, 2006). Sections of the riparian habitat in the watershed have been impacted by development and roads, especially along the shoreline of Long Pond. As development continues, this valuable habitat will diminish - underlining the need for strong protection of the shoreland zone and conservation of undeveloped land within the watershed.

The watershed provides habitat for rare plant and animal species of special concern. MDIF&W documented two rare wildlife occurrences of the Eastern ribbon snake *(Thamnophis sauritus)* in the area around the narrows at Castle Island Rd. between the north and south basins of Long Pond (Figure 11).

Other locally important wildlife species include the American eel (*Anguilla rostrata*) and the common loon (*Gavia immer*). A symbol of summertime on Maine lakes, loons are common on Long Pond, with 42 adult loons and 3 chicks counted on the lake in 2021 (ME Audubon, 2021). BLA kicked off the Loon Preservation Project in 2019 and hired Loon Conservation Associates to conduct a study of loons on Long Pond and Great Pond between 2019 – 2021. As part of this project BLA constructed and installed four floating artificial nests in Long Pond and Great Pond in 2020. Two of the artificial nests were used with a 100% success rate (Loon Conservation Associates, 2020).[21]

According to Beginning with Habitat, large undeveloped forest blocks cover 16,567 acres of the watershed (71% of the watershed). There are 11 areas of inland wading bird and waterfowl habitat in the Long Pond watershed, the largest of which surrounds Ingham Pond, Ingham Stream, and the surrounding wetlands. The largest areas of deer wintering habitat surround the lake's south basin. Protecting the land and water in the Long Pond watershed is vital for maintaining the high-value wildlife habitat existing today. While the exact number of buildable lots remaining in the shoreland zone is currently unknown, the shoreline is already heavily developed. However, the habitat map (previous page) indicates that forestland does provide habitat connectivity for wildlife within the large undeveloped habitat areas that occur in a large portion of the Long Pond watershed.

FISHERIES

Long Pond contains 23 species of fish including coldwater fish that are stocked directly or indirectly into the lake (i.e., splake, rainbow trout, brown trout, and brook trout) (Table 4). While Long Pond supported a renowned coldwater salmon fishery in the 1970s through the 1990s, inadequate spawning and nursery areas necessitated periodic stocking by MDIFW. Stocking of salmon was stopped in 2015 because the illegally introduced landlocked alewives displaced the rainbow smelt, which are the primary forage for landlocked Atlantic salmon, and they were unable to grow without them.[22] Populations of warmwater fish in Long Pond are self-sustaining and do not require stocking.

Deeper areas in the water column experience low levels of dissolved oxygen (DO), which pose a problem for salmonid species like salmon and trout. Salmonids require dissolved oxygen levels above five ppm and will struggle to survive at lower oxygen levels. They also require cold temperatures, so

[21] Success rate in natural nests in Long Pond and Great Pond in 2020 was 22%.

[22] Personal communication. Wes Ashe, MDIFW. Email. March 1, 2022.

their habitat is lakes is often reduced over the course of the summer by low oxygen extending from the bottom of the lake and increasing water temperatures from the top.

Table 4. *Fish species in Long Pond. (Source: MDIFW)*

Species	Scientific Name	Historically Stocked	Currently Stocked	Invasive
Landlocked Alewives	*Alosa pseudoharengus*			
Brown Bullhead	*Ameiurus nebulosus*			
American Eel	*Anguilla rostrata*			
White Sucker	*Catostomus commersoni*			
Slimy Sculpin	*Cottus cognatus*			
Northern Pike	*Esox lucius*			*X*
Chain Pickerel	*Esox niger*			
Redbreast Sunfish	*Lepomis auritus*			
Pumpkinseed Sunfish	*Lepomis gibbosus*			
Common Shiner	*Luxilus cornutus*			
Smallmouth Bass	*Micropterus dolomieu*			
Largemouth Bass	*Micropterus salmoides*			*X*
White Perch	*Morone americana*			
Golden Shiner	*Notemigonus crysoleucas*			
Rainbow Trout	*Oncorhynchus mykiss*		*X*	
Landlocked Rainbow Smelt	*Osmerus mordax*	*X*		
Yellow Perch	*Perca flavescens*			*X*
Black Crappie	*Pomoxis nigromaculatus*			*X*
Brown Trout	*Salmo trutta*			
Brook Trout	*Salvelinus fontinalis*		*X*	
Splake	*Salvelinus fontinalis x namaycush*			
Lake Trout	*Salvelinus namaycush*			
Walleye	*Sander vitreus*			*X*

Long Pond is native habitat for wild Eastern brook trout, a species that is heavily influenced by their environment because they prefer cold water between 50 and 65 °F and thrive in clear, clean, well-oxygenated water. They have been eliminated from much of their native habitat because of their sensitivity to illegally introduced warmwater species like bass and perch (MDIFW, 2022).

Long Pond is not historically accessible to sea-run species, with the exception of the American eel, due to naturally occurring steep gradients downstream of Messalonskee Lake. The elevation gradient from the Kennebec River into Long Pond provides natural barriers to fish passage, beginning in Oakland at the Snow Pond dam, which sits on an approximately 50-foot natural bedrock outcropping.[23] However, the Atlantic salmon and rainbow smelt which were introduced through stocking may utilize small

[23] Personal Communication. Paul Christman, MDMR. Email, 2022.

tributaries and nearshore areas for spawning in lieu of the typical coastal streams above head of tide they use naturally. Thirty-nine stream crossings were identified within the Long Pond watershed.[24] Of these, 18 are round culverts classified as barriers for fish passage and ten are potential barriers for fish passage. The Aquatic Barrier Prioritization online mapper identifies the crossing on Belgrade Rd. over Stony Brook as the highest priority for fish passage to benefit wild eastern brook trout.[25] Replacing undersized culverts with Stream Smart crossings will enhance spawning habitat and reconnect the wetland and stream-pond aquatic habitat functions and values throughout the watershed.

INVASIVE AQUATIC FAUNA

Northern pike *(Esox lucius)* were illegally introduced into Long Pond (via Little North Pond) in the 1960s and are now present in large numbers. Fishing for Northern pike is especially popular in the winter months on Long Pond. Walleye were illegally introduced and may be extirpated but IF&W Biologists cannot yet say with certainty that this is the case (IF&W 2021). The pond also supports a robust smallmouth bass fishery.

In addition to invasive fish, other aquatic invaders have been present in Long Pond for decades. Rusty Crayfish (*Faxonius rusticus*) are identified as posing a great threat to native ecosystems. They has been documented and studied in nearby Great Pond since 1968 (Scott et al., 2010). Rusty Crayfish are an aggressive species, known to displace native crayfish in two ways: through crayfish-to-crayfish competition and by causing increased fish predation on native species. Mudpuppies (*Necturus maculosus*) were accidentally introduced by a Colby College professor in 1939 (Collins, 2003), and have recently been the subject of a new study by biologists at Colby College and MDIFW to better understand their spread and impact (Sarnacki, 2019). Chinese Mystery Snails *(Cipangopaludina chinensis)* were first reported and confirmed in Long Pond in 2009 and their full distribution in Great Pond is currently unknown (VLMP, 2013).

INVASIVE AQUATIC VEGETATION

Variable Water-Milfoil (*Myriophyllum heterophyllum*) is an invasive aquatic species first documented in upstream Great Pond in 2009. It is also present downstream of Long Pond in Belgrade Stream from just below the Wings Mill Dam to Messalonskee Lake. It is extremely well-adapted to a variety of environmental conditions and as such is known to out-compete native aquatic species and quickly forms infestations.

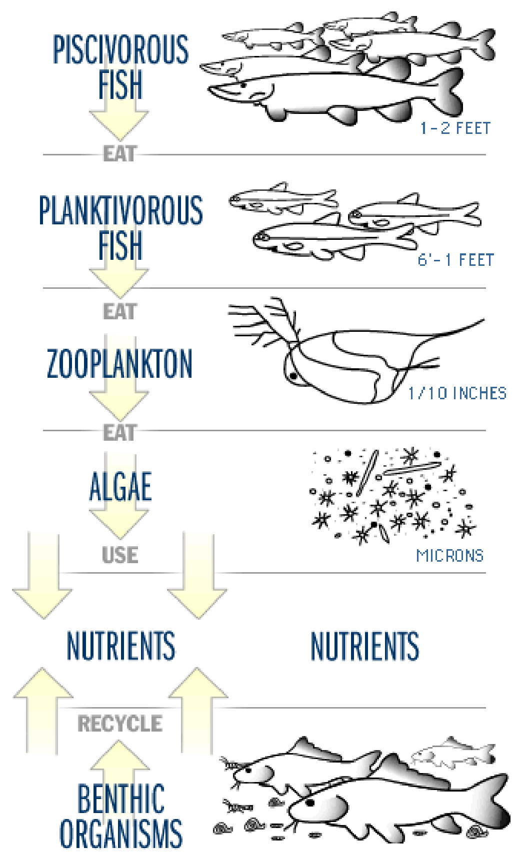
In eight years, $1,273,978 has been raised for milfoil mitigation work in Great Pond and Long Pond. With those funds, 7 Lakes has been able to implement aggressive action plans, employing seasonal workers and an outside contractor, to remove 190,177 gallons of milfoil from Great Pond since it was first documented. The infestation has largely been contained and has not spread into Long Pond.

[24] Maine Stream Habitat Viewer (2016)

[25] https://webapps2.cgis-solutions.com/MaineStreamViewer/

PLANKTON AND CYANOBACTERIA

Tiny aquatic plants (algae, aka phytoplankton) and animals (zooplankton) are the primary and secondary source of food and energy in a lake food web and play a key role in lake ecosystems. Because plankton float in the water column, they influence the transparency of the water throughout the season and from year-to-year as these communities undergo both seasonal and annual growth cycles. These growth cycles vary over the course of the year as a result of changes in temperature, light and nutrient availability.

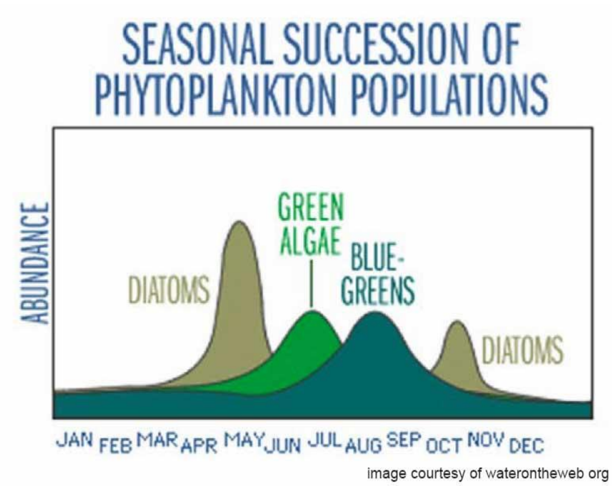


A typical lake food web. (Source: www.waterontheweb.org)

PHYTOPLANKTON

Phytoplankton photosynthesize using the sun's energy to turn carbon dioxide, nutrients and water into food for organisms higher in the food web such as zooplankton and small fish. Phytoplankton are sensitive to changes in lake ecosystems. The effects of environmental and watershed impacts can often be detected in changes in the plankton community species composition, abundance, and biomass.

Water samples are collected in Long Pond by 7 Lakes for phytoplankton analysis at 2 m depths at stations 1 and 2 every two weeks from April - November and analyzed using a FlowCam imaging microscope. The most recent year with multiple months of classified data is 2019, where there are samples from June, July, and August. Plankton images are classified as green algae, golden algae, cyanobacteria, diatoms, or dinoflagellates to observe the changes in community composition through the summer.

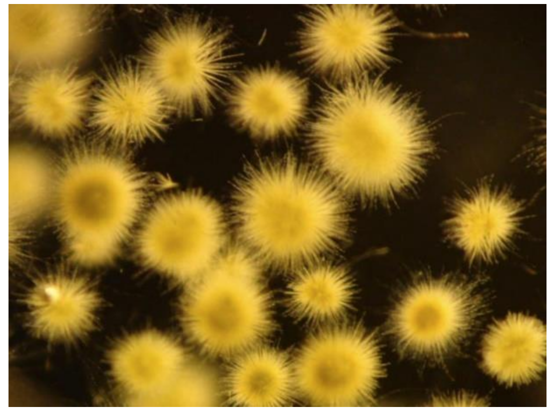


Example of seasonal succession of phytoplankton communities within a lake. (Source: www.waterontheweb.org)

Both the north and south basin of Long Pond have diverse algal communities. In June, the plankton biovolume is highest in both basins and the community is dominated by golden algae. Early season dominance of golden algae is not uncommon in the Belgrades and other Maine lakes. As the summer progresses, cyanobacteria (aka blue-green algae) become more common, particularly in higher-nutrient lakes. Cyanobacteria are present in Long Pond and in lakes all around the world. Their presence, species composition, and abundance can be used as an indicator of water quality. Cyanobacteria, while not true algae, but photosynthetic bacteria that can form dense growths (blooms) in lakes when nutrients are plentiful, water temperature is warm, and sunlight is abundant. These blooms are an indication that the ecology of the lake is out of balance.

GLOEOTRICHIA

A type of cyanobacterium common in Long Pond is *Gloeotrichia echinulata* or *"Gloeo*", which forms small spheres and are big enough to be seen by the naked eye. *Gloeo* grows at the sediment-water interface and then rises through the water column to the surface waters where it completes its life cycle, dies, and sinks back down to the bottom of the lake where it will stay through the winter months until conditions are again suitable for growth (King & Laliberte, 2005). *Gloeo* grows in relatively shallow areas where lake sediments have abundant available phosphorus and there is also adequate light for photosynthesis. It has been observed in Maine lakes for many years, but blooms have increased in lakes throughout the northeast in the recent decades.



Gloeotrichia *echinulata (magnified) in a water sample collected from Great East Lake, ME/NH in 2010. (Source: Jonathan Dufresne, UNH)*

Gloeo blooms have been observed in lakes all over the world with a wide range of trophic states and conditions. *Gloeo* was first recorded in Great Pond in 1987 and has persisted in both Great Pond and Long Pond to the present day. Studies conducted by Colby College in 2005-2006 that included more than 1,500 observations between the two lakes found that *Gloeo* was most abundant during the first week of August, and that significant bloom events were almost always regionalized to the north end of the Long Pond.[26]

Significant *Gloeo* blooms in Long Pond could also influence the movement of P within the lake. When *Gloeo* rises to the surface from deep waters, it brings stored P from the sediments with it, which is a P source that other algae and cyanobacteria in the upper water column can potentially use (King and Laliberte, 2005). The P load associated with *Gloeo* movement into the upper water column from deep water is not accounted for in the internal loading analysis completed as part of this plan.

Since 2015, Long Pond residents have been collecting observational data of *Gloeo* density off their docks using the Bouchard scale (0 – 6) for the duration of the 7 Lakes-Colby Water Quality Initiative (2015-2021). There are currently three volunteer sites on Long Pond, but few observations have been

[26] "FAQ ABOUT GLOEOTRICHIA", Belgrade Lakes Association: https://belgradelakesassociation.org/Portals/0/PDFs/Resources%20Water%20Quality/FAQaboutGLOEOTRICHIA.pdf

recorded on the east and south side of the north basin and the north, east, and south side of the south basin. As wind is an important influence on where *Gloeo* is observed, more volunteer observers from different areas of the pond would allow for a better characterization of *Gloeo* in Long Pond.

METAPHYTON

Maine DEP and LSM have received observational data and reports over the past decade from volunteer lake monitors and watershed associations suggesting a significant increase in metaphyton growth in Maine lakes. Though common throughout the state, implications of an increasing trend are not well understood. There is also limited understanding of the physical, chemical, and biological role these algae play in aquatic ecosystem (Shute & Wilson, 2013). LSM has developed a standardized monitoring protocol to help lake associations and volunteer water quality monitors identify and document the location and density of metaphyton growth in their lake.

Metaphyton mass. (Photo Source: LSM, Betsy & Dick Enright.)

It is well known that some filamentous algae favor environments with increased nutrients including nitrogen (septic systems, for example, can be a direct input of nitrogen into a lake) and P. Because metaphyton, like other freshwater algae, require sunlight and nutrients to survive and thrive, watershed management techniques such as LakeSmart should help decrease metaphyton growth. More research is needed to better understand how and why metaphyton forms in certain areas of the pond. This might include volunteer led surveys of the littoral zone to document the extent of metaphyton in shallow areas of the lake, or a drone survey. Changes in the number of occurrences and area covered by metaphyton will provide another indication of changes in water quality over time.

Metaphyton is filamentous algae typically found in wetlands, floodplains, and the littoral zones of lakes and ponds. It forms loosely aggregated masses or mats that are either attached to benthic substrates or suspended in the water column. Mats can rise to the water surface when oxygen bubbles form within the mass as a result of photosynthesis. Metaphyton begins to form within the littoral zone of a lake or pond shortly after ice-out, persists through the summer months, and begins to degrade in late summer when they sink to the bottom to decompose. The species that make up metaphyton are not cyanobacteria and do not produce toxins.

3. Water Quality Assessment

Water quality data have been collected by Maine DEP and Lake Stewards of Maine (formerly the Volunteer Lake Monitoring Program) in cooperation with the Belgrade Lakes Association since 1970 at the deepest location in each basin (Figure 12). More recent, intensive monitoring has been completed by 7 Lakes and Colby College (2015-2020) which included weekly collection of dissolved oxygen/temperature/pH profiles, water clarity, nutrients, metals, and phytoplankton, as well as sediment sampling. This intensive monitoring effort has continued through 2021, led by staff at 7 Lakes in collaboration with Colby College interns.

A water quality trend analysis was conducted by 7 Lakes for multiple water quality parameters at Stations 1 (north basin) and Station 2 (south basin) which included analysis of the long-term (1970 – 2021) and short-term dataset (last 10-years) using data collected by certified monitors from Lake Stewards of Maine, Maine DEP[1] and 7 Lakes/Colby College. A summary of results for the three primary trophic state indicators (water clarity, chlorophyll-a, and total phosphorus) is presented in Table 5.

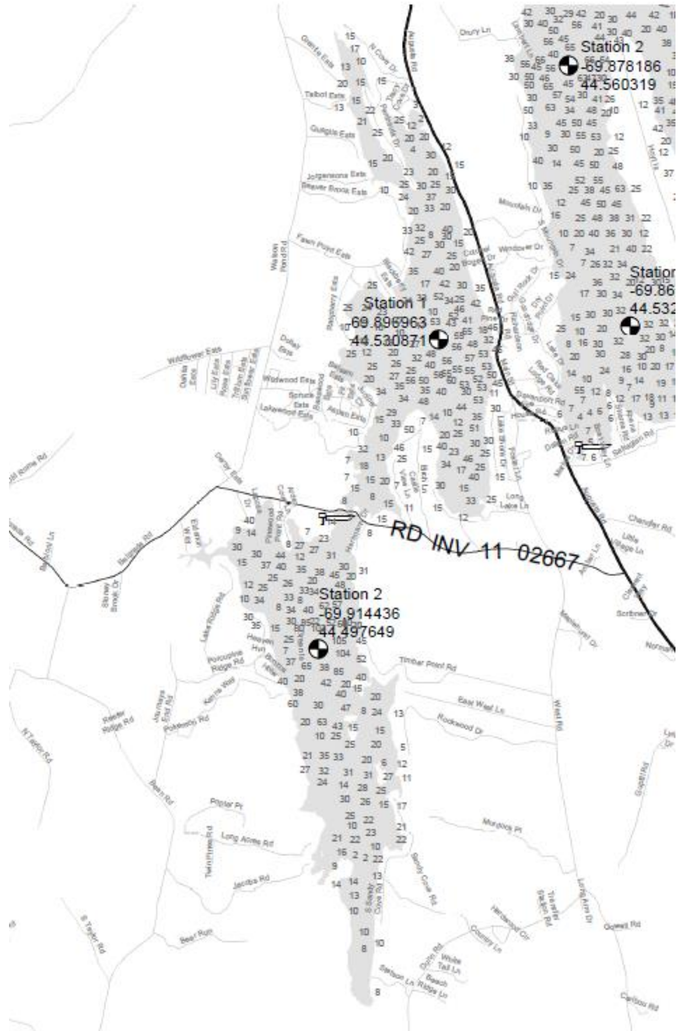


***Figure 12**. Water quality monitoring stations in Long Pond. (Source: LakesofMaine.org)*

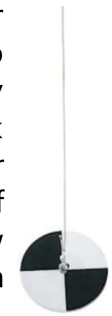
WATER QUALITY TRENDS

WATER CLARITY

Changes in water clarity are measured by slowly lowering a black and white Secchi disk into the water until it is no longer visible and recording the depth. Changes in clarity may be due to increased or decreased algal growth or the amount of dissolved or particulate materials in the lake. A long-term decline is water clarity was the primary listing reason for Long Pond being added to the State's list of impaired lakes in 2006, with a decrease in clarity >1 m over a 30-year period, which makes it an important parameter to track in order to determine if water quality is improving or getting worse over time.

Secchi Disk Transparency (SDT):

A vertical measure of water transparency (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring SDT is one of the most useful ways to show whether a lake is changing from year to year.



Water clarity readings in Long Pond have been collected at Station 1 (north basin) and Station 2 (south basin) since 1970. The long-term dataset includes data from 1970 – 2021, while the short-term dataset includes only the last 10 years of data (2012 – 2021). The recent trend analysis conducted by 7 Lakes indicates **a weak, but significant decrease in water clarity at both stations** with the worst clarity readings in the 2000s. However, over the last 10 years water clarity has stabilized averaging 6.2 m in the north basin, and 6.0 m in the south basin (Figure 13 & Table 5).

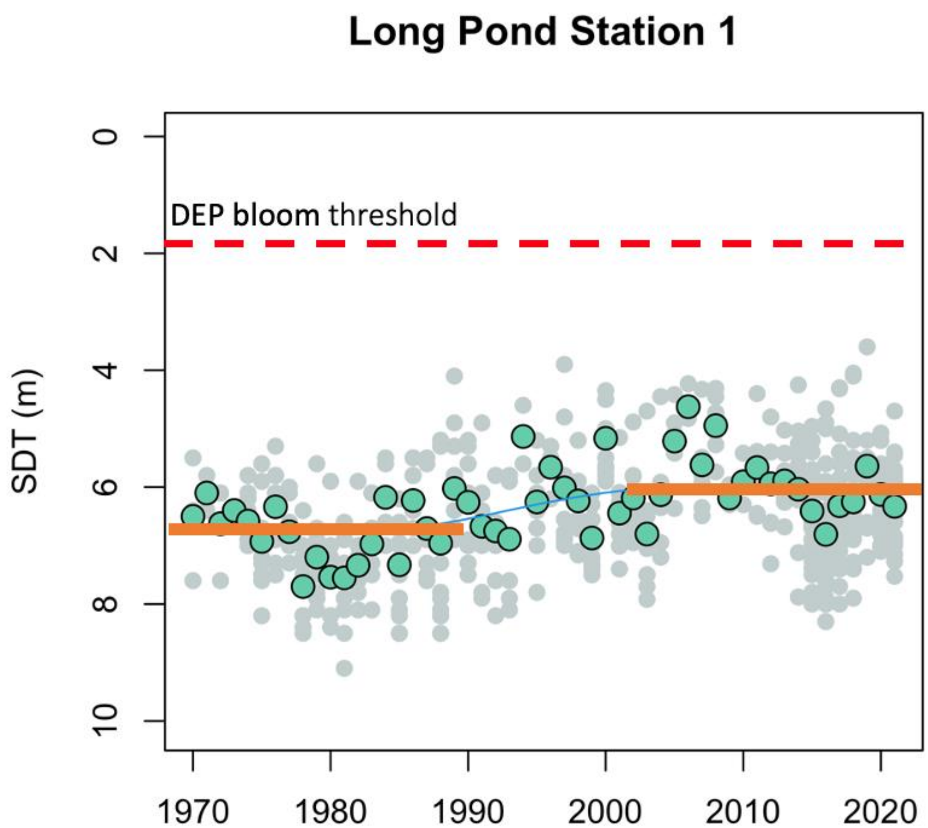


Figure 13. *Long-term water clarity trend at Station 1, north basin. (Source: 7 Lakes Alliance)*

Table 5. *Long and short-term trend analysis results for the three primary trophic state parameters at Long Pond. (LPN = Long Pond North, LPS = Long Pond South) (Data Source: 7 lakes Alliance)*

Water Quality Parameter	Average Annual Water Quality	Trend (Long-Term)	Trend (10-Year)
Water Clarity (m) Long-term Average 10-year Average	**6.3 (LPN), 6.1 (LPS)** **6.2 (LPN), 6.0 (LPS)**	**Weak, but significant decrease in water clarity over long-term in both basins.**	No trend. Water clarity has stabilized over the past 10 years in both basins.
Chlorophyll-a (ppb) Long-term Average 10-year Average	**4.8 (LPN), 4.5 (LPS)** **4.6 (LPN), 4.2 (LPS)**	No trend. Data limited to only a few samples between 1970 – 2000 and only a few years with multiple measurements.	No trend.
Total Phosphorus (ppb) Long-term Average 10-year Average	**8.2 (LPN), 8.6 (LPS)** **8.3 (LPN), 8.3 (LPS)**	No trend.	**Significant decrease in total phosphorus in the south basin.**

CHLOROPHYLL A

Chlorophyll a (Chl-a) is a measure of the green pigment found in all plants including microscopic plants such as algae. Therefore, Chl-a provides a relative estimate of algal biomass where higher Chl-a equates with a higher concentration of algae in the lake. Chl-a and water clarity often track closely since water clarity is an indirect measure of algal abundance. Chl-a is typically collected as an integrated core from the epilimnion as this is typically where temperatures are warmest, light penetration strongest, and where plants, including algae, grow.

Chl-a measurements in Long Pond have been collected at Station 1 (north basin) and Station 2 (south basin) since 1976 however, limited data exists before 2000, and in the past twenty years annual averages most often represent a single sample. Based on the trend analysis conducted by 7 Lakes, **there is no trend in Chl-a at either station**. Average annual Chl-a over the last 10 years is 4.6 in the north basin and 4.2 in the south basin (Table 5). A review of decadal trends shows the highest Chl-a in the 2000s (same period of the lowest water clarity).

TOTAL PHOSPHORUS

Total phosphorus (TP) is the total concentration of phosphorus including organic and inorganic forms. TP is one of the major nutrients needed for plant growth and is generally present in small amounts in freshwater, thereby limiting plant (and algae) growth. As TP increases in a lake, generally the amount of algae also increases. Humans add phosphorus to a lake through stormwater runoff, lawn or garden fertilizers, agricultural runoff and leaky or poorly maintained septic systems. P can also be released from the lake's bottom sediments when there is no oxygen at the sediment water interface

> ***Epilimnion*** **–** the upper layer of a thermally stratified lake. The epilimnion is typically warm as a result of the sun penetrating the water's surface and high in oxygen due to mixing from wind.

(internal loading); it can eventually reach the upper layers of the lake profile through mixing or diffusion, where it fuels algal growth.

TP data used for this analysis include water samples collected by Maine DEP between 1976 – 2018 from the epilimnion.[27] TP in the north basin has ranged from 5 ppb (September 1982) – 16 ppb (June 2000) with a long-term annual average of 8.2 ppb and 8.3 ppb based on the 10-year dataset. TP in the south basin has ranged from 5 ppb (May 2009) – 16 ppb (August 1999) with a long-term annual average of 8.6 ppb, and 8.3 ppb based on the 10-year dataset. While long-term trends indicate TP has not changed significantly (likely due to high variability in the dataset), the **10-year trend in the south basin indicates a statistically significant decrease in TP** (Figure 14 & Table 5).

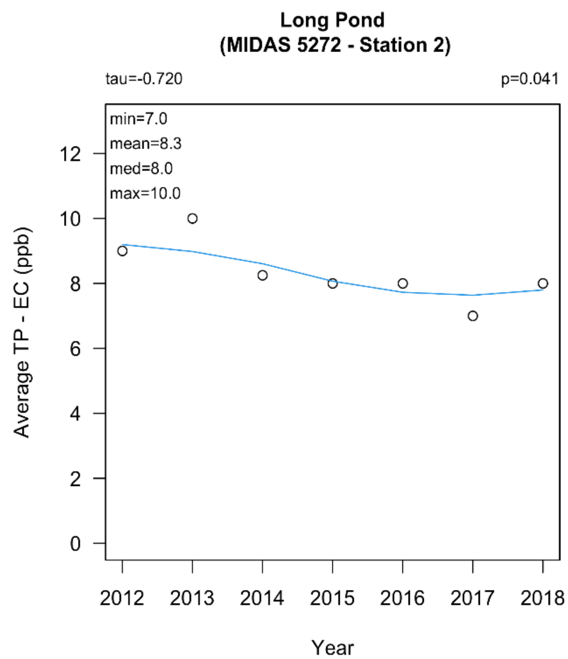


Figure 14. *Annual average TP trend for Long Pond, Station 2 (south basin) showing a significant decrease in TP between 2012-2018. (Source: 7 Lakes Alliance)*

Overall, the long-term water clarity trend indicates a slight decline, yet the short-term trend at both stations indicates that water clarity has stabilized over the last 10 years. Chl-a is also stable, lacking a trend in either direction. TP is stable in the north basin and appears to have decreased (improvement in water quality) in the south basin over the last 10 years.

When compared to the numerical guidelines for evaluation of trophic state in Maine, Long Pond is considered mesotrophic (Table 6). Mesotrophic lakes have elevated nutrient levels and are moderately productive. These lakes are in a transitional stage between oligotrophic (clear, minimal plant growth)

[27] The 2022 WRS loading analysis used both DEP data (collected approximately once/year), as well as 7 Lakes/Colby data from 2015 – 2021 which includes P profile data throughout the water column over the course of the open water season (April – November). This allowed for a volume weighted TP concentrations that are slightly lower than the concentrations calculated using only DEP data (8.2 ppb north basin, 7.8 ppb south basin- see Appendix E).

and eutrophic (murky and muddy with elevated plant growth) stages. Long Pond falls in the middle of the mesotrophic range for all three parameters.

Table 6. *10-year averages for primary trophic state parameters in Long Pond compared to numerical guidelines for evaluation of trophic status in Maine. (Data Source: 7 Lakes Alliance)*

	Long Pond 10-Yr Average	ME DEP Trophic Status Indicators			Long Pond Classification
		Oligotrophic	Mesotrophic	Eutrophic	
Water Clarity (m) Station 1 (north basin) Station 2 (south basin)	**6.2** **6.0**	**> 8**	**4 – 8**	**< 4**	**Mesotrophic**
Chlorophyll-a (ppb) Station 1 (north basin) Station 2 (south basin)	**4.5** **4.2**	**< 1.5**	**1.5 – 7**	**> 7**	**Mesotrophic**
Total Phosphorus (ppb) Station 1 (north basin) Station 2 (south basin)	**8.3** **8.3**	**< 4.5**	**4.5 – 20**	**> 20**	**Mesotrophic**

DISSOLVED OXYGEN & TEMPERATURE

Dissolved oxygen (DO) refers to concentration of oxygen dissolved in the water, which is vital to fish, zooplankton, vertebrates, and chemical reactions that support lake functioning. DO levels below 5 ppm can stress some species of coldwater fish, and over time reduce habitat for sensitive coldwater species. DO concentrations in lake water are influenced by several factors, including water temperature, stratification, concentration of algae and other plants in the water, decomposition, and the amount of nutrients and organic matter flowing into the lake as runoff from the watershed.

Summer DO concentrations can change dramatically with lake depth, as oxygen is produced in the top portion of the lake where sunlight drives photosynthesis and winds continuously mix water and air. Oxygen consumption dominates near the bottom of the lake where organic matter accumulates and decomposes, and water is cut off from wind mixing when the lake is stratified. In seasonally stratified lakes, such as Long Pond, the DO concentrations from top to bottom can be very different, with high levels of oxygen near the surface and little to no oxygen near the bottom, especially during the summer and early fall when water temperature and decomposition are at their highest. Stratification prevents atmospheric oxygen (wind, wave mixing) from reaching the deep areas, cutting off the supply. In addition, microbial respiration (microbes breaking down decaying plant and animal matter) at the bottom of the lake consumes oxygen, the combination of which results in loss of DO in deep areas of the lake (anoxia).

Hypolimnion – the bottom layer of a thermally stratified lake. The hypolimnion is typically cooler and may be lower in oxygen than the warmer, oxygenated epilimnion above.

Thermal stratification, anoxia, and sediment chemistry can result in the release of P from the sediments (internal loading) which can fuel algal growth and lead to persistent, recurring nuisance algal blooms.

To examine seasonal patterns of temperature and DO, the 7 Lakes-Colby Water Quality Initiative collected data throughout the water column at both stations. This includes SDT and DO/temperature profiles weekly to biweekly between April - November at both stations, and water samples collected every two to four weeks at 2 m or 4 m intervals for TP. This dataset provides information about the onset and extent of anoxia across the open water sampling season and throughout the water column.

In the north basin of Long Pond, stratification begins in June and continues until the lake begins to turn over (mix) in October. The onset of anoxia occurs in July and lasts until the lake is fully mixed, usually in November. The concentration of P increases in the bottom waters during this period, and eventually reaches the upper waters, frequently resulting in the lowest water clarity readings (refer to temperature and oxygen "heat maps" in Appendix C).

In the south basin onset of stratification also begins in June and turnover begins in October. Anoxic conditions start in July, but anoxic waters in the south basin occupy a much smaller volume of water and have less contact with sediment area than in the north basin. High P concentrations are observed in this anoxic region. The south basin also has a region of low oxygen in the middle of the water column, called a metalimnetic oxygen minimum (MOM) (Figure 15). More work needs to be done to understand the formation, extent, and impact of the Long Pond MOM, but there does not appear to be an increase of P in this layer as there is at the lake bottom.

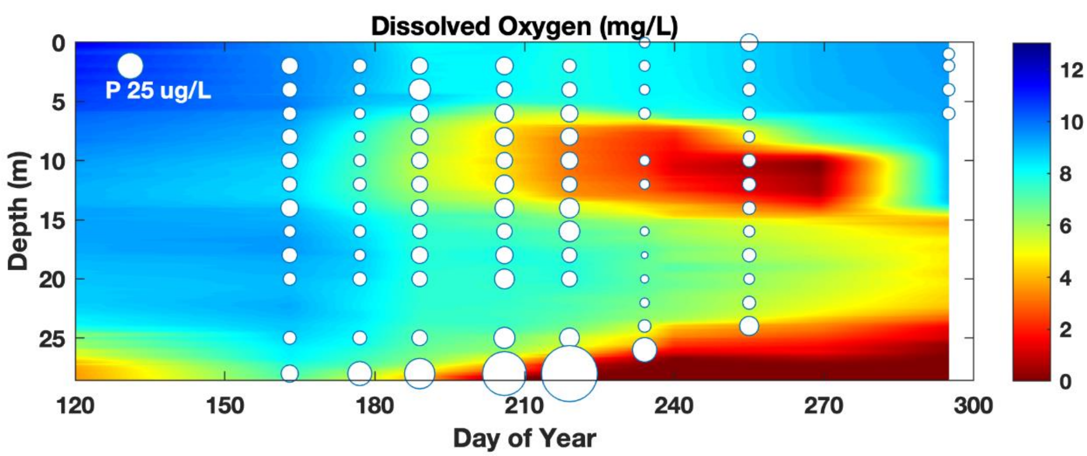


Figure 15. *2019 dissolved oxygen and phosphorus concentrations by depth in Long Pond, Station 2 (south basin). (White circles represent the concentration of phosphorus at each depth in the water column.) (Source: 7 Lakes Alliance)*

To evaluate trends in anoxia, the anoxic factor was calculated for both basins. Anoxic factor (AF) is a metric that combines the volume of anoxic water (DO < 2 mg/L) and the length of time that the lake is anoxic. Larger values of anoxic factor indicate poorer water quality. Profile measurements of dissolved oxygen from Lake Stewards of Maine were used to compute the anoxic factor in a given year, as long as there were at least six profiles. This included 17 years between 1989 and 2018. A Mann-Kendall trend analysis indicates **a weak but significant increase in anoxic factor in the north basin** of Long Pond (Figure 16), and no significant change in the south basin. The average, minimum and maximum anoxic factor values in the north basin were all higher than the south basin. The metalimnetic oxygen minimum in the south basin was not included in these calculations.

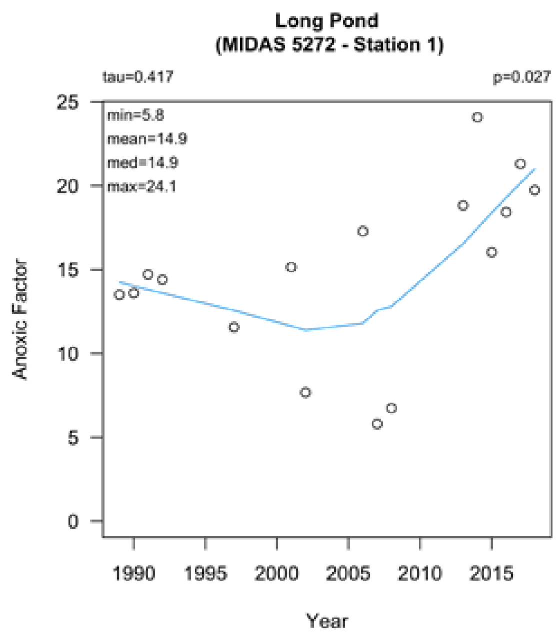


Figure 16. *A Mann-Kendall trend analysis for Anoxic Factor (AF) at Station 1 (north basin) indicates a weak statistically significant increase in AF since 1989. (Source: 7 Lakes Alliance)*

Should AF continue to increase in the north basin, it could lead to an increase in the mass of P at the bottom of the lake due to the increased area of sediment exposed to anoxia and an increase in the length of time that P is available to algae during the growing season. Once the MOM in the south basin is further assessed, it may have some bearing on AF and P release that is not currently accounted for in the analysis.

CONDITION ANALYSIS

Maine DEP recently published a classification and condition analysis for Maine lakes (Deeds, 2020). Based on this analysis, Long Pond is classified as a "coastal deep lake", and its watershed is in the "intermediate" condition class due to the level of human activity it contains. Table 7 (below) presents the ranges of water quality parameters observed in coastal ponds for each condition class.

***Table 7**. Coastal pond lake type: water quality parameter ranges (Maine DEP).*

	Condition Classes			Long Pond
Parameter	**Reference**	**Intermediate**	**Altered**	
Total Phosphorus - Epilimnion Core (ppb)	<8.3 ± 0.7	**8.3-13.4**	> 13.4 ± 4	**8.3**
Specific Conductivity (µS/cm)	< 34.2 ± 3.2	**34.2-66.3**	≥ 66.3 ± 4	**48.0**

According to this analysis, Long Pond falls within the range for 'Intermediate' coastal lakes for both specific conductivity and total phosphorus. TP can be indicative of watershed development, while specific conductivity is directly related to the level of dissolved ions in the water. Higher levels of conductivity can indicate a greater concentration of contaminants such as septic system leachate and road salt.

4. Watershed Modeling

A review of P loading in Long Pond was conducted by Water Resource Services (WRS) to revise P load estimates previously used for the 2008 TMDL and 2009 WBMP, and by WRS in 2016. The revised P loading estimate utilized data from Maine DEP through 2018 and 7 Lakes/Colby College from 2015 – 2021.

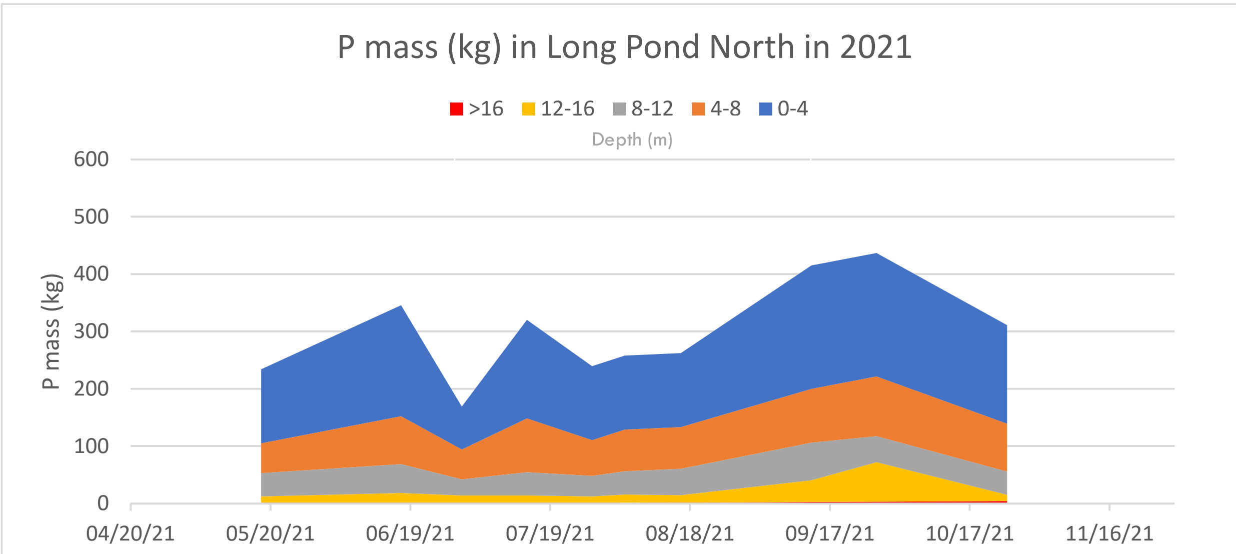
Major differences between data sets used for previous P estimates and the recent estimate include: **1)** use of a more robust dataset that includes P profiles from 7 Lakes that provides a more reliable estimate P mass and the pattern of P mass throughout the sampling season in each basin between 2015 – 2021, **2)** updated bathymetric data provided by Colby College that results in a slightly larger area and volume for the north basin but slightly deeper mean depth for the south basin, and **3)** a smaller surface area, watershed area, and volume of water for the south basin as a result of reassigning the section of Belgrade Stream from the south end of Long Pond to the Wings Mill Dam to the Messalonskee Lake watershed. Below are some important outcomes from the 2022 modeling update:

- WQ trends- Examination of SDT, TP and Chl-a data for the periods 1976 – 2013 and 2014 – 2019 agree with the 7 Lakes water quality analysis indicating that the average of the older and more recent datasets are not significantly different.
- Anoxic Factor (AF) is lower in the south basin (<10) but increased dramatically in the north basin using the more recent bathymetry (16.4)[28] with oxygen depletion occurring at depths greater than 9 to 10 m by end of summer and exposing up to a third of the lake bottom to low oxygen and possible P release.
- MOM- The cause of the metalimnetic oxygen minimum (MOM) is not well understood but is not expected to result in a release of sediment-bound P due to the area of oxygenated water located between the MOM and documented deep water anoxia. However, the MOM could be a source of P to overlying water and could promote growth of *Gloeo.*
- Variability in P mass- Calculation of the mass of P in each layer of water in each basin over the past seven years (2015 – 2021) shows a variable pattern in each basin from year to year, but in general P mass declines in June and again in August. The variation in P mass in the spring

[28] AF values >10 represent a concern and therefore additional calculations may be needed to verify this increase.

across years appears to be related to/similar to the mass of P in the water in the water column the previous fall.

- P mass and importance of external vs. internal load- The majority of the P mass is located in the top 8 m of the water column (in the epilimnion) of both basins which increases and decreases throughout the growing season but does not appear strongly impacted by internal loading of P from the sediments. This indicates that P release from sediments exposed to low oxygen is a minor component of the total P mass in either basin compared to the mass of watershed-derived P at the surface of the lake (Figure 17 & Appendix E).



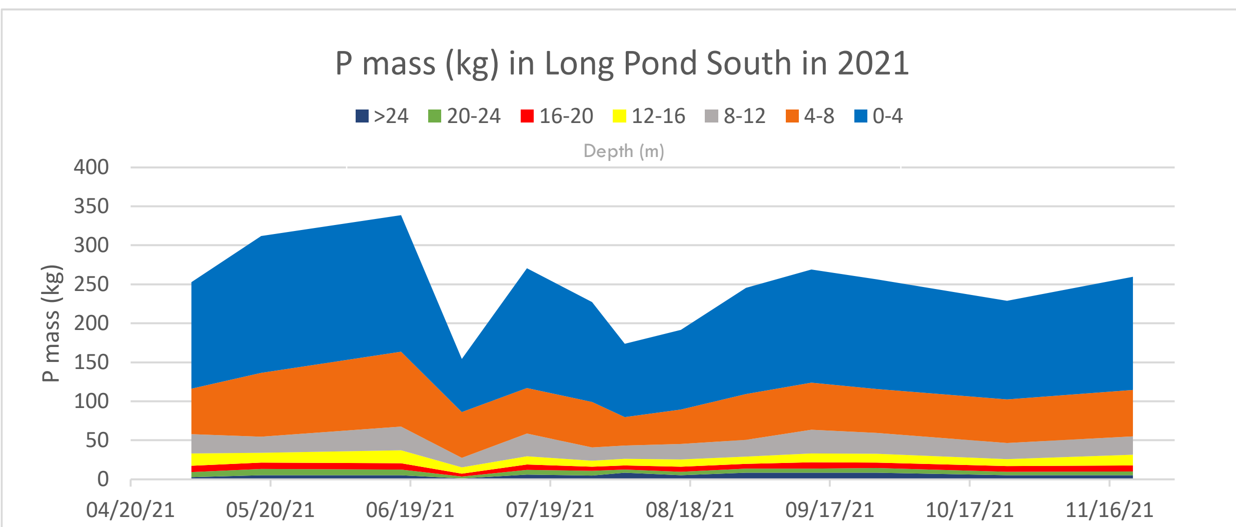
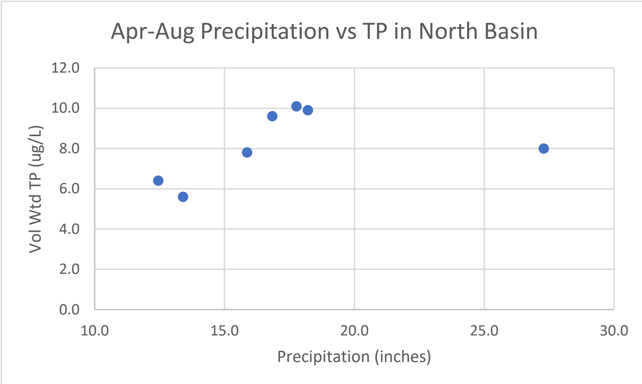


Figure 17. *Phosphorus mass in the north (top) and south (bottom) basins of Long Pond in 2021. (Source: WRS, 2022)*

- P and Precipitation- A comparison of volume-weighted P concentrations for both basins was compared with precipitation data for the area and found to result in a correlation between P and precipitation between April – August, with increased precipitation resulting in increased P (Figure 18).



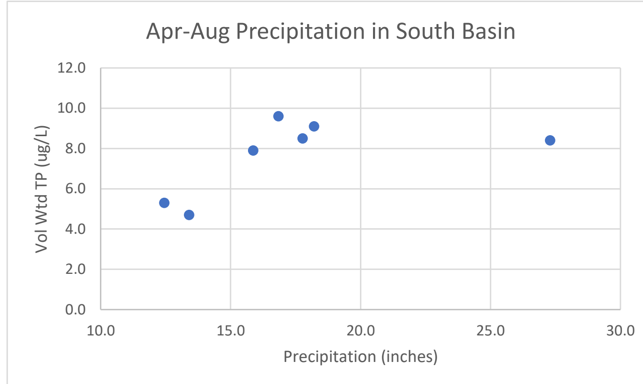


Figure 18*. Precipitation vs. phosphorus concentration in the north basin (left) and south basin (right) of Long Pond (2015 – 2021). (Source: WRS, 2022)*

This suggests that precipitation interacting with watershed features is likely one of the most important determinants of the P concentration in both basins, and an especially important consideration for watershed management.

EMPIRICAL MODELING

Updated P loading estimates calculated by WRS utilized empirical models to predict P loads and P concentrations in Long Pond using recent in-lake water quality data. The models were used to make predictions about potential increases in P concentrations in Long Pond under several different climate scenarios, as well as expected decreases in P with the application of watershed management activities. These estimates were used to set water quality goals for Long Pond over the next 10-year planning period. A full description of the model inputs and outputs is provided in Appendix E.

The empirical models are used to back-calculate the P load necessary to produce the observed P concentrations in each basin. The P loads are then compared to the best empirical estimates that could be derived based on basin features (Table 8) and allocated to six major P sources: **1)** atmospheric inputs (precipitation), **2)** groundwater/wastewater inflows (septic systems), **3)** direct drainage, **4)** indirect drainage, **5)** waterfowl, and **6)** internal load. Figure 19 shows the location of the indirect drainages in relation to the direct drainages of the north and south basins. Great Pond makes up over half of the combined direct and indirect drainage areas (53%) followed by the south basin (18%) and north basins (13%) of Long Pond. The other three indirect drainages make up the remaining 16% of the drainage area (Table 9).

Indirect drainages (Great Pond, Kidder Pond, and Whittier Pond) play an important role in the delivery of water and nutrients to the north basin of Long Pond, with Great Pond alone contributing 78% of the water load to the north basin with an additional 6% of the water load from the combined drainages of Kidder and Whittier Ponds. Similarly, the north basin of Long Pond contributes 80% of the water load to the south basin of Long Pond with an additional 7% from the Ingham Pond indirect drainage (Figure 20).

Table 8. *Model parameter values and results, Long Pond. (Source: WRS, 2022)*

Model Parameter		North Basin	South Basin
TP Concentration	(ppb)	8.2	7.7
Phosphorus Load to Lake	(g P/m^2/yr)	0.287	0.376
Phosphorus Load to Lake	(kg/yr)	1,476	1,543
Influent (inflow) TP	(ppb)	11.9	10.2
Inflow	(m^3/yr)	124,200,000	150,900,000
Lake Area	(m^2)	5,100,000	4,100,000
Lake Volume	(m^3)	38,300,000	31,000,000
Mean Depth	(m)	7.51	7.56
Flushing Rate	flushes/yr	3.24	4.87

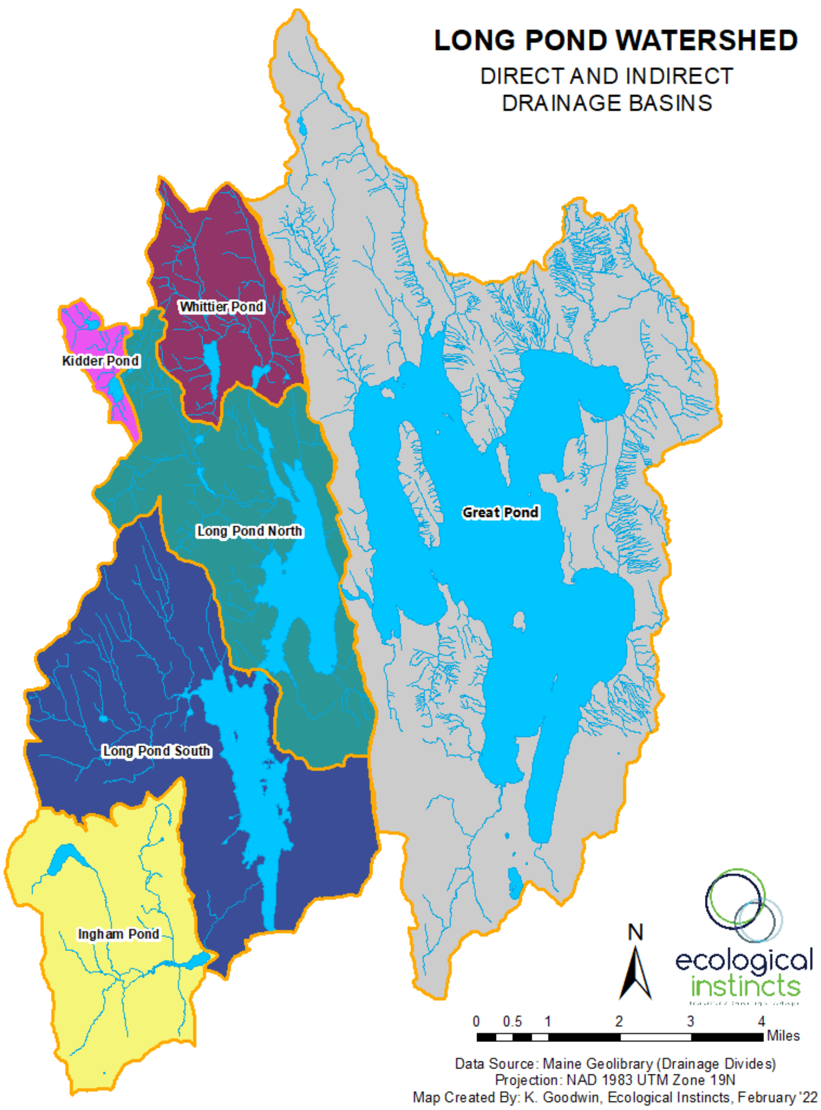


Figure 19. *Direct and indirect drainage basins of Long Pond.*

The estimated P load to the north basin of Long Pond based on the 2022 modeling update is 1,463 kg/yr (Table 10), and 1,560 kg/yr to the south basin (Table 11). The total load to each basin is lower than previous estimates, and there is considerable overlap among source types. This is likely attributed to revised lake and watershed areas, recent water quality data, and supported by the fact that the loads are very similar to the average loads derived from the empirical models. Waterfowl was the only category with no change from previous estimates because there is no real data available. All of the changes from previous estimates within categories decreased with the exception of the groundwater inputs, including septic systems, which resulted in an increase in P load from this category due to increased development over the past two decades (applied as a 10% increase in P from previous estimates).

By far the largest source of P in the north basin is the outflow from Great Pond, estimated at 59% of the total load compared to 12% from the direct drainage of the north basin, and another 5% from the combined inputs from the Whittier Pond and Kidder Pond indirect drainages (Figure 20). **Similarly, the largest source of P in the south basin is the outflow from the north basin accounting for 62% of the total load** compared to just under 19% from the direct drainage of the south basin and 5% from Ingham Pond.

Table 9. *Watershed area for the Long Pond direct and indirect drainages (includes lake surface area).*

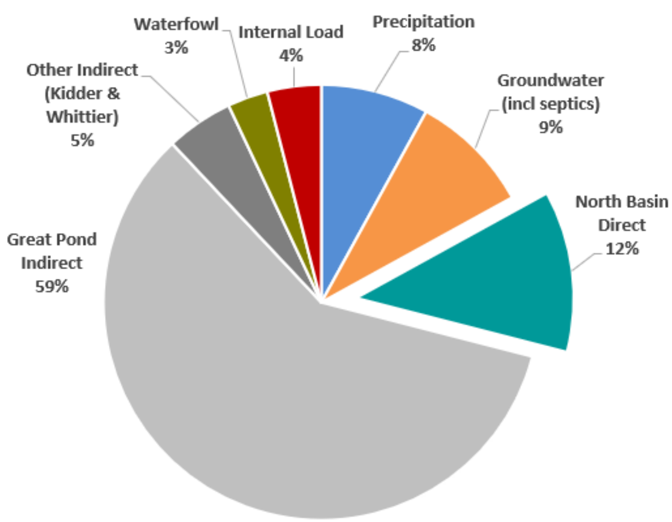
Drainage Basin	Area (acres)	% of Total
Long Pond (north basin)	7,287	13%
Great Pond	*29,077*	*53%*
Kidder Pond	*621*	*1%*
Whittier Pond	*3,153*	*6%*
Long Pond (south basin)	9,827	18%
Ingham Pond	*5,048*	*9%*
Total Watershed Area	**55,013**	**100%**

Table 10. *Itemized P loading for the north basin of Long Pond. (Modified from WRS, 2022)*

Model Parameter	Water Load	% of Water Load	P Load	% of P Load
(North Basin)	*(mm^3/yr)*	*%*	*(kg/yr)*	*%*
Direct Precipitation	5.3	4%	111	8%
Direct Groundwater (incl septics)	1.9	2%	138	9%
Surface Flow				
Direct Drainage	12.6	10%	176	12%
Great Pond Indirect Drainage	96.5	78%	868	59%
Whittier Pond Indirect Drainage	6.6	5%	52	4%
Kidder Pond Indirect Drainage	1.3	1%	11	1%
Discharges	0	0%		0%
Waterfowl	0	0%	50	3%
Internal Release	0	0%	57	4%
Total North Basin	**124.2**	**100%**	**1,463**	**100%**

Table 11. *Itemized P loading for the south basin of Long Pond. (Modified from WRS, 2022)*

Model Parameter	Water Load	% of Water Load	P Load	% of P Load
(South Basin)	*(mm³/yr)*	*%*	*(kg/yr)*	*%*
Direct Precipitation	4.26	3%	89	6%
Direct Groundwater (incl septics)	1.42	<1%	56	4%
Surface Flow				
Direct Drainage	13.3	9%	287	19%
From North Basin	121.3	80%	973	62%
Ingham Pond Indirect Drainage	10.6	7%	84	5.4%
Discharges	0	0%	0	0%
Waterfowl	0	0%	50	3%
Internal Release	0	0%	21	1%
Total South Basin	**150.9**	**100%**	**1,560**	**100%**



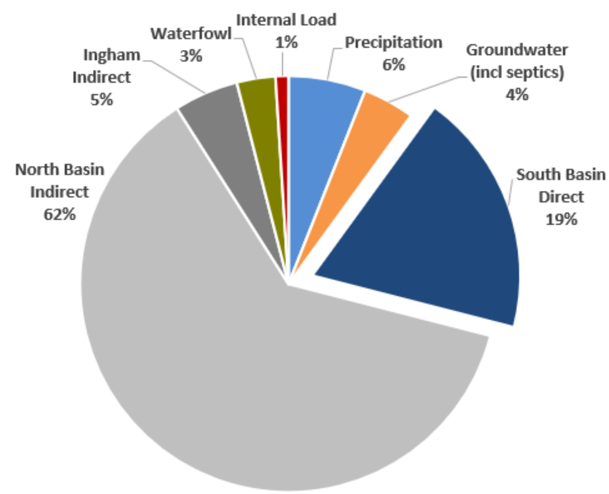


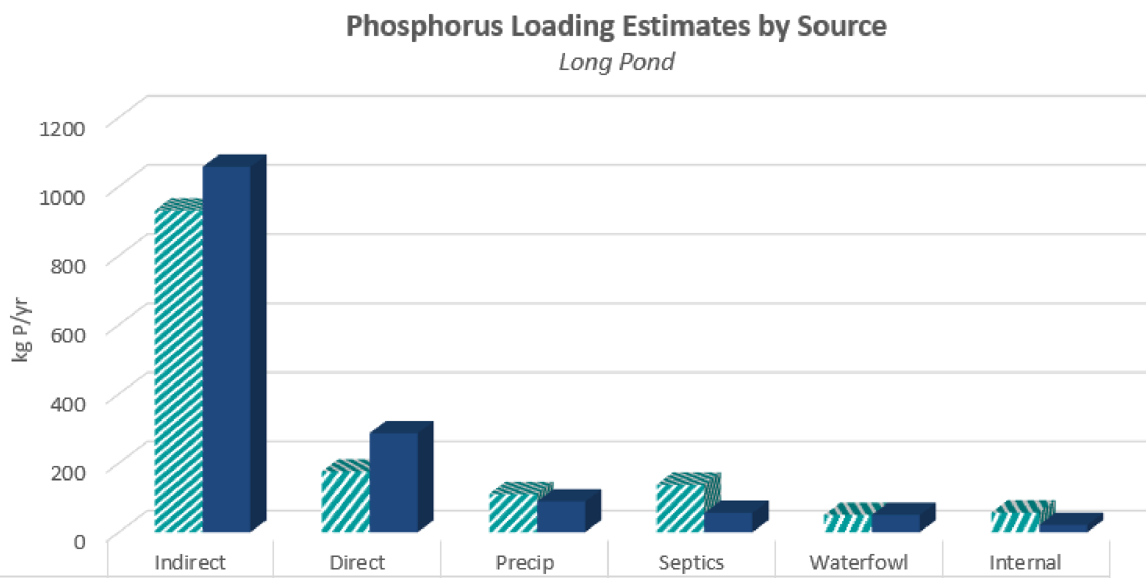
Figure 20. *P loads by type for the north basin (left) and south basin (right) of Long Pond.*

The internal P load is a small fraction of the total load in the north and south basins, estimated at 4% and 1% of the load, respectively, while P from groundwater including septic systems provides a slightly larger load at 9% and 4% in the north and south basins, respectively. Other natural sources such as waterfowl and atmospheric deposition of P from direct precipitation landing on the surface of the lake make up an additional 11% in the north basin and 9% in the south basin.

A side-by-side comparison of P loading by basin (expressed as mass) sheds additional insight regarding the similarities in P loading in the north and south basins (Figure 21). P loading in both basins is dominated by inflow from the upstream watersheds with the south basin receiving a slightly higher indirect load than the north basin. The direct load in the south basin is larger than the north likely because the direct watershed of the south basin is larger despite less development on the shoreline.

The estimate of septic loading in the north basin is more than double the estimate for the south basin due to the greater amount of shoreline development, and internal loading is also more than double in the north basin due to the anoxic conditions described in the previous chapter. However, the total loads differ by only 3% with a slightly higher total load to the south basin.

Despite slightly lower total loading estimates in each basin compared to previous estimates, the primary management conclusions for managing P in the Long Pond watershed have not changed. **Results of this analysis indicate that while management of P from developed areas in the Long Pond watershed is an important and necessary planning priority, <u>the highest priority for reducing P inputs to Long Pond is addressing the outflow from Great Pond.</u>**



	Indirect	Direct	Precip	Septics	Waterfowl	Internal
North Basin	931	176	111	138	50	57
South Basin	1057	287	89	56	50	21

Figure 21. *P loads by type for the north basin (left) and south basin (right) of Long Pond.*

FUTURE LOADING SCENARIOS

Future loading scenarios including future development in the watershed, climate change, and addressing current sources of pollution in the watershed were evaluated by WRS to assist with water quality goal setting and planning strategies for Long Pond over the next 10 years. A full explanation of the various scenarios including the criteria used for each scenario, and the expected water quality outcome is provided in Appendix E and summarized below.

Future Development

For development, the key factors are impervious surfaces leading to more runoff and residential practices leading to more P available to be washed into streams and lakes. Roads, roofs, driveways, and even lawns on packed soils shift the fate of precipitation from infiltration to runoff. Fertilization and lawn waste (e.g., grass, leaves) handling can lead to higher organic and total P loading to water resources. Best management practices are intended to minimize impacts by source control and pollutant trapping, but even the best controls do not completely counter development impacts. To estimate the expected increase in P loading from future development in the watershed, P loading for a 10 year period of the 100-year projected buildout (FBE, 2009a) was used in the empirical model and the influence from septic systems was also increased by 10% resulting in an **increase of 18 – 25 kg P/yr in the north basin and 16 - 25 kg P/yr in the south basin** for future development with and without P controls, respectively. This reflects a minor increase in the in-lake TP concentration (0.1 ppb north basin – 0.2 ppb south basin) based on development without P controls (Table 12). With P controls in place for all new development, there would be no measurable increase in the in-lake P concentration in the south basin, and only a small increase in the north basin which could be offset by addressing current sources of P on previously developed land in the watershed.

Climate Change

The major effects of climate change are discussed in Section 5. To estimate the expected increase in P loading caused by climate change in the Long Pond watershed, total annual precipitation was increased within the empirical watershed model by 2% and 10% resulting an in an **increase of 28 – 139 kg P/yr in the north basin and 31 – 153 kg P/yr in the south basin.** This reflects a minor increase in the in-lake TP concentration in the north basin (0.1 ppb) based on the 10% increase in precipitation (Table 12).

Watershed Management (Address Current Sources of P)

Addressing current sources of NPS pollution in the watershed through the application of BMPs on shoreline residential properties, roads, municipal properties, septic systems, and agricultural land throughout the watershed will help offset the effects of future development and climate change. P load reduction estimates for the 2020 watershed survey sites (which included the smaller indirect drainages in the Long Pond watershed), and a watershed approach to address other land cover types that were not part of the watershed survey (e.g., timber harvests and agricultural land) were factored into load reduction estimates using the Maine DEP Relational Method (Appendix D). **Addressing current sources of NPS pollution in the both the direct and indirect drainages is expected to result in an 86 and 38 kg/yr P reduction** in the north and south basins, respectively, **and reduce the in-lake concentration by 0.5 ppb in both basins** (Table 12).

The majority of the P reduction in the north basin (54% or 50 kg/yr) is attributed to addressing current sources of NPS pollution in the Great Pond watershed.[29] Similarly, 71% of the P reduction in the south basin is attributed to watershed management in the indirect drainages (60 kg/yr north basin, 10 kg/yr Kidder Pond) compared to 22% (22 kg/yr) from the direct drainage of the south basin. Improving

[29]The water quality goal for the Great Pond WBMP is to reduce in-lake TP by 0.5 ppb which will result in a direct benefit water quality in downstream Long Pond.

septic systems would account for an additional 16% (14 kg/yr) of the expected P reduction in the north basin, and 6% (6 kg/yr) in the south basin.

Table 12. *Phosphorus loading scenarios for Long Pond from future development, climate change and addressing current sources of NPS pollution in the watershed.*

Future Loading Scenario	North Basin (ppb)	South Basin (ppb)	Change in TP* (ppb)
Current Conditions	8.3	8.3	
Watershed Management	7.8	7.8	**0.5 ppb Decrease**
Climate Change (10% increase in precip)	8.4	8.3	**0 - 0.1 ppb Increase**
Future Development (No P Controls)	8.4	8.3	**0.1 - 0.2 ppb Increase**
Future Development & Climate Change	8.6	8.4	**0.1 - 0.3 ppb Increase**

**Results may vary by +/- 10% as expected for the total load, and possibly more when considering climate change.*

Results of this exercise reinforce the need for addressing current sources of NPS pollution to offset the potential effects from future development and climate change. Adopting municipal ordinances that require strict P standards for all new development rather than just large developments and subdivisions will provide a long-term strategy for protecting the water quality of Long Pond well beyond the 10-year WBMP planning period.

WATER QUALITY TARGET SELECTION

A revised water quality target was selected by the project's steering committee following review of the water quality analysis and watershed model update. The current water quality trends indicate that water clarity has stabilized over the past 5 -10 years and P concentrations in the south basin have declined while other water quality parameters have not changed significantly in the last 10 years. Modeling presented in the previous section indicates that watershed management in the direct and indirect watersheds is needed to address current sources of NPS pollution to offset the expected increased P load from future development and climate change. While a 0.5 ppb decrease in in-lake P could be achieved in both basins through watershed management over the next 10 years, future development and climate change will increase loading by an estimated 0.1 ppb (south basin) – 0.3 ppb (north basin). Therefore, **watershed management to reduce phosphorus from current sources of NPS pollution <u>is essential</u> for improving water quality.**

Watershed-wide P control ordinances for future development, and management of existing sources of NPS pollution are needed to offset the expected increase in P loading to Long Pond over the next 10 years and beyond. **An in-lake water quality target of 8.1 ppb in the north basin and 7.9 ppb**

in the south basin will account for the expected changes in P loading to the lake from both natural and human-induced sources (Figure 22). An important management strategy is to target upstream sources of P first, starting with the Great Pond watershed because it is the greatest source of P to Long Pond.

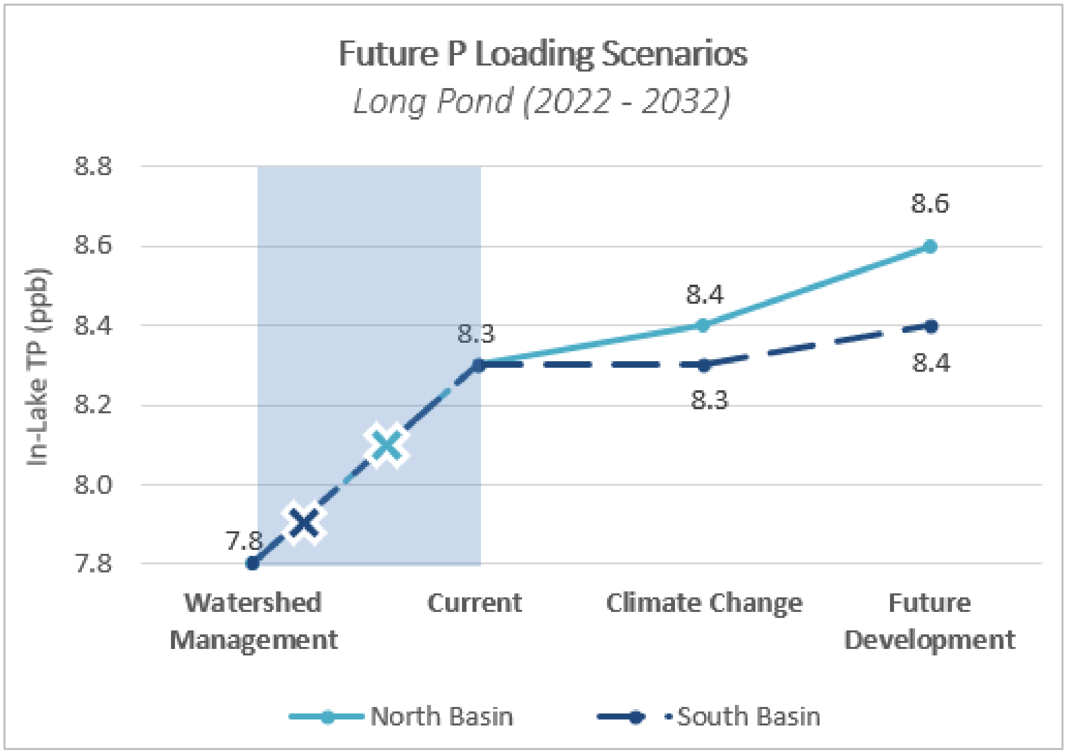


Figure 22. *Future P loading scenarios for Long Pond.*

5. Climate Change Adaptation

Current Maine DEP guidance calls for developing watershed management plans that incorporate climate change considerations. This guidance would be addressed to a large extent by any plan that focuses on stormwater inputs and minimzing the internal P load. The primary climate change impacts on lakes are variation in precipitation and temperature. Higher precipitation periods, usually involving more intense storms, lead to more runoff and greater nutrient loading.

Higher (air and water) temperatures lead to earlier ice-out and later ice-in, resulting in longer and stronger stratification periods, which leads to increased algal growth, greater oxygen demand due to decomposition on the lake bottom, lower oxygen near the lake bottom, and increased phosphorus release from surficial sediments where iron is a major phosphorus binder (internal loading). Warmer water temperatures and increased P also favor invasive species, cyanobacteria, and harmful algal blooms (HABs) that produce toxins harmful to humans and wildlife. Increasing temperature and dissolved organic carbon (DOC) in lakes has a direct effect on thermal and biological dynamics, ultimately favoring nutrient-loving species (like toxin-producing cyanobacteria) over species adapted to cooler water temperatures.

Winter sunset on Long Pond. (Photo Credit: Carol Johnson)

Between 2015 – 2020, the Gulf of Maine experienced its warmest 5-year period on record (Pershing, et. al., 2021), warming at a rate seven times faster than the rest of the ocean. A 2020 report from the Maine Climate Council confirms that over the last several decades, air and surface water temperatures have been increasing in Maine. Surface water temperatures in northern New England increased 1.4 °F per decade from 1984-2014, which is faster than the worldwide average, with Maine lakes warming on average by nearly 5.5 °F during this time. Data also show that smaller lakes and ponds are warming more rapidly than larger lakes.

Movement toward bigger and more frequent storms presents another challenge for watershed management and exacerbates the internal loading problem as more intense rainfall will increase the amount of nutrient transport to the lake from the watershed via stormwater runoff that will be available for algal growth. Phosphorus loading is very strongly connected to precipitation, and disrupting that relationship is not an easy task.

These climate-related changes are likely to exacerbate water quality issues in Long Pond, necessitating additional P load reductions from watershed sources to offset the anticipated increases due to climate change. Though water quality in many Maine lakes has improved as a result of laws and regulations that protect water quality by mitigating the effects of human development, the effects of climate change threaten the effectiveness of these dated laws that may need adjusting to adequately protect natural resources in the future (MCC, 2020).

Watershed modeling estimates **an additional 28 – 139 kg P/yr in the north basin and 31 – 153 kg P/yr in the south basin from the direct and indirect watersheds could be delivered to Long Pond with an increase in precipitation of 2-10%.** It is important to remember that the watershed is not a static system, and the phosphorus load will continue increasing over time without taking actions to address these changes. The estimated increase above could be exceeded with just a few unforeseen large-scale climatic events that deliver a lot of sediment to the lake in a single pulse. If P inputs are allowed to increase, costly remediation measures could become necessary to address cycles of internal loading that may develop. Climate change adaptation planning, such as upgrading infrastructure on roads (i.e., undersized culverts), infiltrating stormwater runoff on commercial and residential properties, planting buffers, and conserving undeveloped land, can help to counteract the effects of the anticipated increase in precipitation. Infiltration of stormwater runoff reduces runoff volume, decreases P through filtration and adsorption, and importantly, decreases the temperature of the runoff water.

A good starting point for adaptation planning includes formation of a Community Climate Change Committee and development of a Climate Change Action Plan that incorporates a watershed climate model. The plan would include a prioritized list of community actions using guidance from the Maine Climate Council and the Maine DEP's Adaptation Toolkit. A more detailed list of planning actions to mitigate the effects of climate change is presented in Section 7.

6. Establishment of Water Quality Goals

Findings from the current evaluation of water quality data and watershed modeling align with the findings of the 2009 WBMP- that reducing P loading from the direct watershed of Long Pond alone will not achieve desired water quality conditions due to the dominant influence of the indirect watershed of Great Pond.

A team of scientists and local stakeholders worked collaboratively over several months to set a revised water quality goal for Long Pond that would help stabilize and improve water quality trends in Long Pond. Specifically, the committee reviewed the results of the water quality analysis conducted by 7 Lakes (Appendix C) and revised phosphorus loading estimates and future loading scenarios provided by WRS (Appendix E). Previous watershed assessment work, including a watershed survey, NPS implementation projects, and active YCC and LakeSmart programs were evaluated to determine if revised water quality goals could be met based on past performance and proposed load reduction estimates.

Accounting for future development and climate change, the goal of this plan is to reduce P from the watershed load by approximately 6% in each basin (86 kg/yr north basin and 68 kg/yr south basin) which is expected to

"P" REDUCTIONS NEEDED

North Basin: - 86 kg/yr
16 kg/yr direct watershed
56 kg/yr indirect watersheds
14 kg/yr septic systems

South Basin: - 38 kg/yr
22 kg/yr direct watershed
10 kg/yr indirect watersheds
6 kg/yr septic systems

Timeframe: 2022- 2032

Projects: Erosion Control BMPs, YCC, LakeSmart, septic upgrades

WATER QUALITY RESTORATION GOAL

Long Pond has stable or improving water quality trends

In-Lake P (north basin) = 8.1 ppb

In-Lake P (south basin) = 7.9 ppb

reduce the average annual in-lake TP concentration from 8.3 ppb to 8.1 ppb in the north basin, and from 8.3 ppb to 7.9 ppb in the south basin. This can be achieved by:

- Reducing the external load in the direct watershed of the north basin by 16 kg/yr.
- Reducing the external load in the direct watershed of the south basin by 22 kg/yr.
- Reducing the external load to the north basin from indirect watersheds including Great Pond (54 kg/yr) and Whittier Pond (2 kg/yr).
- Reducing the external load to the south basin indirect watershed (Ingham Pond, 10 kg/yr).[30]
- Reduce P loading from septic systems by 14 kg/yr in the north basin and 6 kg/yr in the south basin.

7. Watershed Action Plan & Management Measures

The Long Pond WBMP provides strategies for achieving the water quality goal. These recommendations are outlined in detail in the plan and were presented to the steering committee for review and feedback. The action plan represents solutions for improving water quality in Long Pond based on the best available science.

The action plan is divided into five major objectives, along with a schedule for completion, description of potential funding sources, and a list of project partners assigned to each task. The objectives focus on:

1) **Reducing the External P Load**
2) **Preventing New Sources of NPS Pollution**
3) **Education, Outreach & Communications**
4) **Building Local Capacity**
5) **Long-Term Monitoring & Assessment**

REDUCING THE EXTERNAL LOAD

Addressing NPS pollution from watershed sources is an important part of a multi-step process to improve the water quality in Long Pond. Addressing the external load will require ongoing work annually over the ten-year period and beyond. Cooperation from landowners, towns, and businesses will be needed to successfully reduce the watershed P load by 124 kg/yr.

[30] A 60 kg reduction is expected in the south basin as a result of P reductions from upstream Great Pond and the north basin of Long Pond. This reduction is not reflected in the total reduction needed because it is an indirect result of P reductions that have already been accounted for in the reductions for the north basin.

Load reductions were estimated for Long Pond using US EPA Region 5 model to estimate P reductions that can be achieved by addressing NPS sites from the 2020 watershed survey (14 kg/yr),[31] Maine DEP Relational method to estimate load reductions based on the fraction of the total P load from various developed land cover types in the watershed (18 kg north basin, 32 kg south basin), and watershed modeling conducted by WRS (86 kg/yr north basin, 38 kg/yr south basin). The use of the three different models assisted with developing the best estimates for load reductions to Long Pond. A summary of methods for calculating load reductions is provided in Appendix D.

By integrating these three models, the **total estimated P load reduction required for Long Pond is 124 kg/yr** including 38 kg/yr from the direct watersheds of the north and south basins, 66 kg/yr from the smaller indirect watersheds, and 20 kg/yr from septic systems.[32]

Based on the Relational Method, P reductions apply to the following land use types in the Long Pond watershed: 19 kg/yr from shoreline and non-shoreline development (8.5 kg/yr north basin, 10.8 kg/yr south basin), 15 kg/yr from roads including paved and gravel roads throughout the watershed (6.4 kg/yr north basin, 8.6 kg/yr south basin), 14 kg/yr from agricultural land (2.2 kg/yr north basin, 11.4 kg/yr south basin), and <2 kg/yr from timber harvesting (0.6 kg/yr north basin, 0.9 kg/yr south basin). Load reductions from the Relational Method were separated by subdrainage[33] by Ecological Instincts for use by WRS in the empirical model, which included 16 kg/yr north basin direct, 2 kg/yr Whittier Pond, 0 kg/yr Kidder Pond**,** 22 kg/yr south basin direct, and 10 kg/yr Ingham Pond.

Using the load reductions estimated above, WRS estimated total load reductions that could be achieved by reducing P through practical application of BMPs in the watershed in both the Long Pond and Great Pond watershed. Because of the large influence of Great Pond on the P load in the north basin, and the downstream influence of the north basin on the south basin, additional reductions above what was applied in the direct watershed of the south basin can be achieved by reducing the load to Great Pond. Additional non-direct load reductions from the empirical model:

a. **North Basin (68 kg/yr)-** An additional 54 kg/yr from reducing the watershed load in the Great Pond watershed, and 14 kg P/yr reduction from groundwater/septic systems;
b. **South Basin (66 kg/yr)**- 60 kg/yr reduction from north basin reductions (direct & indirect load reductions) and a 6 kg/yr reduction from groundwater/septic systems.

WATERSHED NPS SITES

In 2020, volunteers and technical staff identified 148 sites across the watershed that contribute nonpoint source pollution to Long Pond (Figure 23 & Appendix A).

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[31] Based on a soil P concentration of 0.00012 lbs P/lb soil.

[32] An additional 60 kg P/yr reduction of the indirect load in the south basin (from the north basin) is not included in this total. The P reduction from the north basin to the south basin is the result of P reductions from watershed management in the watersheds of upstream Great Pond and the direct watershed of the north basin.

[33] Based on the % of sites by basin from the 2020 watershed survey.

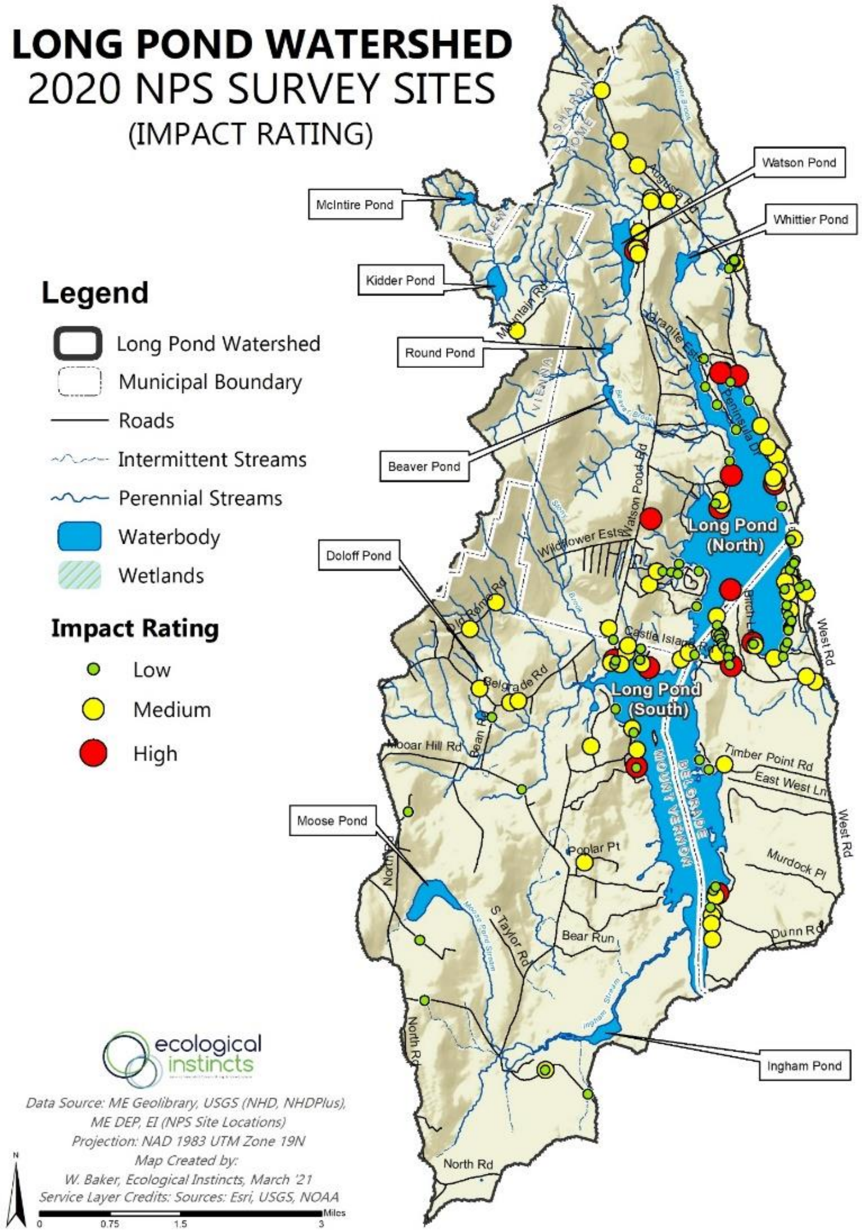


Figure 23. *High, medium, and low-impact NPS sites from the 2020 Long Pond watershed survey.*

Sites were documented across 12 different land-use types (Figure 24 & Table 13). The number of residential properties far outweighed the other land-use types. The impact that documented NPS sites may have on the water quality of Long Pond was determined during the survey based on the proximity to a waterbody and the magnitude of the problem. Factors such as slope, amount of eroding soil, and buffer size were also considered. A closer look at the estimated impact of these sites shows that while there are a total of 148 sites documented, only 16 rank high-impact compared to 61 medium, and 71 low-impact sites (Table 13). Residential NPS sites make up the greatest number of high, medium, and low-impact sites, accounting for 43% of all sites, and 55% of the low-impact sites. Roads and driveways make up the next largest category of NPS sites with 41% of all sites, and 67% are high or medium impact.

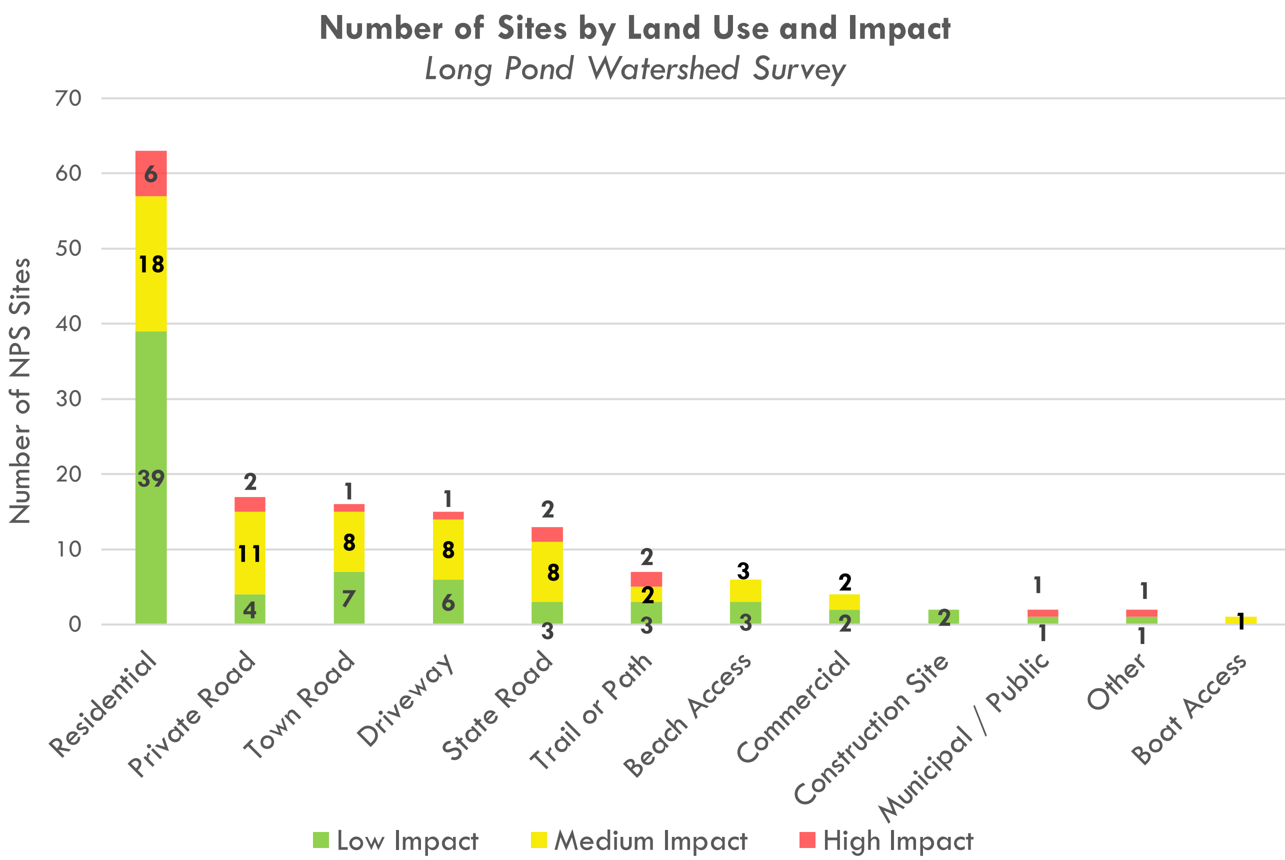


Figure 24. *Number of NPS sites identified in the Long Pond watershed by land use and impact.*

Table 13. *Summary of NPS sites in the Long Pond watershed by land use and impact.*

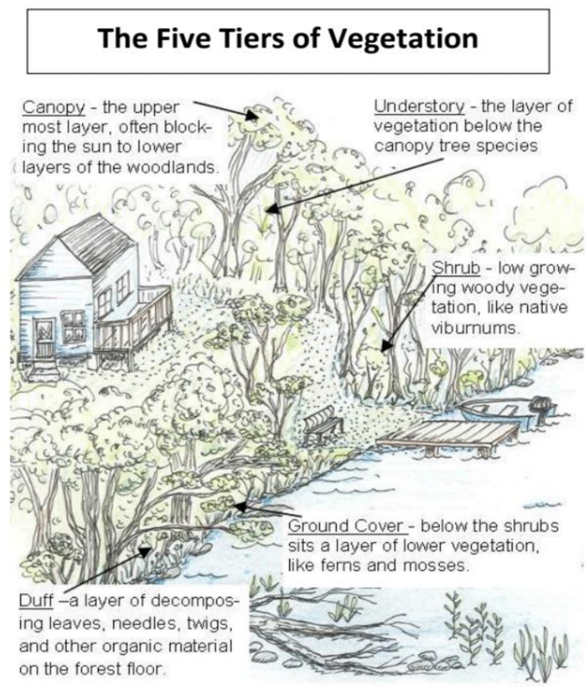
Land Use	High Impact	Medium Impact	Low Impact	Total	% of Total
Residential	6	18	39	**63**	**43%**
Private Road	2	11	4	**17**	**11%**
Town Road	1	8	7	**16**	**11%**
Driveway	1	8	6	**15**	**10%**
State Road	2	8	3	**13**	**9%**
Trail or Path	2	2	3	**7**	**5%**
Beach Access	0	3	3	**6**	**4%**
Commercial	0	2	2	**4**	**3%**
Construction Site	0	0	2	**2**	**1%**
Municipal / Public	1	0	1	**2**	**1%**
Other	1	0	1	**2**	**1%**
Boat Access	0	1	0	**1**	**1%**
Total	**16**	**61**	**71**	**148**	**100%**

BUFFERS

Installing an effective shoreline buffer can be one of the easiest ways to help improve water quality. Natural vegetated shorelines are often the "last line of defense" for trapping and treating polluted stormwater runoff before it gets to the lake. A healthy, vegetated shoreline will not only act as a buffer between the lake and adjacent shoreline development but will also provide great benefit to wildlife as more species live in (and rely on) shoreline riparian zones than any other habitat type (Maine Audubon, 2006). Increasing development pressure throughout the watershed, and especially within the shoreland zone of Long Pond, and the effects of climate change (more frequent and more intense precipitation and increased volume and velocity of stormwater runoff) means that healthy, vegetated shoreline buffers will be even more important for achieving water quality goals and maintaining a healthy lake ecosystem.

Shoreline buffer installation on a lakefront property. (Source: https://www.uwp.edu)

The 2020 watershed survey confirmed a general lack of effective shoreline buffers at residential properties on Long Pond. 7 Lakes currently runs a LakeSmart program that has certified 115 properties on Long Pond. This plan recommends continuing to encourage shorefront property owners to participate in the program, with the goal of 25% of shorefront properties participating by 2032. LakeSmart currently requires a vegetative buffer zone that is at least 10-feet deep (on average) comprised of all three of the vegetation stand types (ground cover: <2 ft, small trees and shrubs: <6ft, and trees and large shrubs: >6ft) to ensure that stormwater runoff is captured and infiltrated within the buffer, raindrops are interrupted by overstory vegetation, and the overall function of the shoreline is maximized.



Example of an effective shoreline buffer with five tiers of vegetation. (Source: Maine Lakes)

Outreach efforts will include a buffer campaign with easy-to-follow guidance for installing effective shoreline buffers highlighting the importance of **buffer quality**- as a healthy and functioning shoreline buffer includes more than just the installation of native plantings. The quality of the soil and a healthy duff layer is just as important when constructing an effective vegetated shoreline.

In addition to encouraging participation in the LakeSmart program, several phases of federal grants (particularly Clean Water Act Section 319 grants awarded by the US EPA to Maine DEP) will be sought to address high and medium-impact sites on commercial properties, driveways, and residential properties on the shoreline, with a goal of addressing 16 high-impact sites, 61 medium-impact sites, and 71 low-impact sites over the next 10 years, along with 160 sites not identified in the watershed survey. Many low-impact sites will also be addressed by the YCC, which installs an average of 18 BMP erosion control projects on Long Pond each year.

The following actions are recommended for reducing the external load by addressing NPS sites in the watershed. A detailed planning schedule, potential funding sources, and estimated costs for 14 related actions is provided below.

AGRICULTURE AND FORESTRY

Active agricultural and forestry in the watershed were not reviewed beyond what could be seen from roadways during the 2020 watershed survey, and more information is needed to determine what impact timber harvesting and agriculture may have on P loading to Long Pond. This plan recommends meeting with the United States Department of Agriculture (USDA)/Natural Resources Conservation Services (NRCS) to assess impacts from these land uses and offer technical assistance to address NPS impacts. Where possible, watershed lands should be maintained as, or restored to, forestland. Because clean water is a natural by-product of a healthy forest, policy makers should promote land use practices that encourage landowners to maintain forested watershed parcels whenever practical.

ADDRESS DOCUMENTED NPS SITES
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A. Reduce External Phosphorus Load (NPS Sites)					
A1	Review list of **77 high and medium priority sites outlined in the 2020 watershed survey** and develop a **candidate site list** for future 319 grant applications	Years 1-10	7 Lakes, steering committee	7 Lakes	$2,000
A2	Assess the impact of **agriculture and logging** in the watershed by hosting meetings with USDA/NRCS to create an inventory, better understand extent of impact, and offer technical assistance to address NPS problems	Years 3-5	7 Lakes, KCSWCD, USDA/NRCS	7 Lakes	$2,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
Address High & Medium Impact NPS Sites (117 sites total: 77 survey, 40 new)					
A3	Address NPS sites on residential properties ***Goal: 24 residential sites (6 high & 18 medium impact)***	Years 2-10	7 Lakes (YCC), Landowners	US EPA (319), Maine DEP, Landowners	$28,800
A4	Address NPS sites on state and town roads and public properties ***Goal: 19 sites (3 high impact, 16 medium impact)***	Years 2-10	7 Lakes, Towns, Maine DOT	US EPA (319), Maine DEP, MDOT, Towns of Belgrade, Rome, Mount Vernon (Towns)	$95,000
A5	Address NPS sites on private gravel roads ***Goal: 13 sites (2 high impact, 11 medium impact)***	Years 2-10	7 Lakes, Road Associations, Landowners	US EPA (319), Maine DEP, Landowners, Road Associations	$45,500
A6	Address NPS sites on driveways ***Goal: 9 driveway sites (1 high impact, 8 medium impact)***	Years 2-10	7 Lakes, Landowners	US EPA (319), Maine DEP, Landowners	$22,500
A7	Address NPS sites on "Other" sites (e.g., boat access, commercial, trail/path, etc.) ***Goal: 12 sites (4 high impact, 8 medium impact)***	Years 2-10	7 Lakes, Landowners	US EPA (319), Maine DEP, 7 Lakes (YCC), Landowners	$19,200
A8	Address new NPS sites not identified in 2020 watershed survey ***Goal: 40 sites (10 high impact, 30 medium impact)***	Years 2-10	7 Lakes, Towns, Road Associations, Landowners	US EPA (319), Maine DEP, 7 Lakes (YCC), Landowners	$160,000
Address Low Impact NPS Sites (191 sites total: 71 survey, 50 buffer, 70 new)					
A9	Work with residential property owners to address low-impact residential NPS sites (including trails/paths, beach access, construction, other) ***Goal: Address 100% of low-impact residential related sites (48 sites)***	Years 1-10	7 Lakes, Landowners	Landowners, 7 Lakes (YCC)	$57,600
A10	Target shorefront properties to become LakeSmart ***Goal: 25% of shorefront property owners participating by 2032***	Years 1-10	7 Lakes, BLA, Landowners	Landowners, 7 Lakes, BLA, US EPA (319), Maine DEP	$70,000
A11	Install residential buffers on non-NPS list properties ***Goal: Install new or improve existing buffers on 50 residential properties (non-watershed survey sites)***	Years 1-10	7 Lakes, BLA, Landowners	Landowners, 7 Lakes (YCC), BLA	$60,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
A12	Work with road associations and homeowners to address low-impact private road and driveway sites ***Goal: Address 10 low-impact road sites***	Years 2-10	7 Lakes, Road Associations, Landowners	Road Associations, 7 Lakes	$20,000
A13	Address other low-impact sites on state/town roads, public, and commercial properties ***Goal: Address 13 other NPS sites***	Years 2-10	7 Lakes, Towns, Maine DOT	Maine DOT, Towns, 7 Lakes	$15,600
A14	Address new low impact NPS sites not identified in 2020 watershed survey ***Goal: 70 new low-impact sites***	Years 2-10	7 Lakes, Landowners	Landowners, 7 Lakes (YCC)	$84,000
External Phosphorus Load (NPS Sites) Subtotal					**$682,200**

SEPTIC SYSTEMS

While P loading from septic systems appears to have a relatively small impact on the water quality of Long Pond based on the watershed modeling (only 9% of loading comes from groundwater including septic systems in the north basin and 4% in the west basin), there are still many unknowns about their impact. Just one or two failing septic systems leaching nutrient-rich wastewater into the lake could result in localized water quality problems. Proposed load reduction targets from septic systems are conservative estimates that can be further refined when more information is available regarding the state of septic systems in the watershed. The following actions are recommended for reducing the external load from septic systems in the watershed. A detailed planning schedule, potential funding sources, and estimated costs for seven related actions is provided below.

REDUCE NPS FROM SEPTIC SYSTEMS
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
Reduce NPS from Septic Systems					
A15	Continue BLA **septic inspection and pumping rebate program** to encourage timely maintenance	Years 1-10	BLA	BLA	$10,000
A15	Prepare a **septic system database** with known state septic records & update following a septic survey and annual requests to watershed towns	Years 3-10	7 Lakes, Colby, Consultant, Towns	Grants, 7 Lakes, BLA	$6,000
A16	Use Vulnerable Soils map to identify property owners on parcels with **at-**	Years 3-10	7 Lakes, Maine State Soil Scientist	Grants, 7 Lakes, BLA	$6,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
	risk soils and old or aging systems and offer technical assistance.				
A17	Consider implementing a system for **tracking septic inspections** conducted for real estate transfers in the shoreland zone; this may include an ordinance that requires new landowners to submit inspection reports to the town	Years 3-10	Towns of Belgrade, Rome, Mount Vernon	Grants, 7 Lakes, Towns	$14,000
A18	Consider making available **DEP Small Community Septic System grants** for malfunctioning systems to eligible landowners with high priority systems.	Years 5-10	Towns of Belgrade, Rome, Mount Vernon	7 Lakes	$3,000
A19	Consider requiring **septic system inspections for properties in the shoreland zone** when properties change from seasonal to year-round use, and require replacement if systems fail	Years 5-10	Towns of Belgrade, Rome, Mount Vernon	Towns	$5,000
A20	Consider requiring septic system inspections for **rental properties in the shoreland zone** to minimize impacts from undersized septic systems	Years 5-10	Towns of Belgrade, Rome, Mount Vernon	Towns	$10,000
External Phosphorus Load (Septic Systems) Subtotal					**$54,000**
Reducing the External Load Total					**$736,200**

PREVENT NEW SOURCES OF NPS POLLUTION

Preventing new sources of P from getting into the lake will be key to the success of the management strategies described above. As the water quality in the lake improves, Long Pond will continue to be a desirable place to live and to visit, resulting in new development in the watershed. Prevention strategies will include ongoing public education, municipal planning, and land conservation.

FUTURE DEVELOPMENT, MUNICIPAL PLANNING & CONSERVATION

Many towns in the watershed already have ordinances in place to protect their lakes and ponds from polluted runoff. However, even in towns where these ordinances are already in place it is likely that many older structures do not meet the current standards set by these ordinances. Along with new construction on the remaining undeveloped shoreline parcels, conversion of seasonal or second homes to year-round homes is the most likely shift in usage along the shoreline, thereby increasing the potential for additional stormwater runoff to the lake as a result of increased use (e.g., fertilizing, clearing vegetation, raking, compacted soil areas from vehicles and foot traffic), and related impacts from septic systems. Ensuring that regulations are in place to address runoff from conversions of structures in the shoreland zone will be important for protecting water quality.

Roads and driveways built to access new development can deliver large quantities of sediment and attached P if not built correctly or maintained properly. (Photo Credit: BLA)

Protecting high-value riparian habitat through land conservation in order to safeguard small headwater streams and large areas of undeveloped forests should be a consideration over the next 10-year planning period.

Below are the major recommendations from the Long Pond steering committee and Technical Advisory Committee related to reducing impacts from future development. A detailed planning schedule, potential funding sources, and estimated costs for 12 related actions is provided below.

PREVENT NEW SOURCES OF NPS (FUTURE DEVELOPMENT) ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
B. Prevent New Sources of NPS Pollution					
General Tasks					
B1	Attend regular Select Board meetings to update towns about watershed activities and needs ***Goal: Minimum 2 meetings/town/year***	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$3,000
B2	Work with town officials on **winter sand and salt** issues including cleanup and ongoing road maintenance	Years 1-10	7 Lakes, BLA	7 Lakes	$2,000
B3	Work with landowners/road associations to conduct regular road maintenance on **gravel roads**	Years 1-10	7 Lakes	7 Lakes	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
B4	Work with local landscape nurseries to provide discounts for buffer plantings ***Goal: 3-5 local nurseries participating***	Years 1-10	7 Lakes	7 Lakes	$3,000
Future Development & Conservation					
B5	Continue working with landowners to protect undeveloped land throughout the watershed ***Goal: 2,000 acres conserved (not including cost of land)***	Years 1-10	7 Lakes	7 Lakes	$50,000
B6	Update the 2009 **build-out analysis**, comparing original projections to current development patterns, and update projections for next 20 years	Years 5-10	Consultant	7 Lakes, grant	$5,000
Municipal Planning					
B7	Encourage towns to **expand hours for code enforcement** officers to adequately enforce current ordinances	Years 1-10	BLA, 7 Lakes	7 Lakes, Towns, Landowners	$2,000
B8	**Review town ordinances** to determine what improvements have been made since the 2009 assessment, and what work is still needed to improve ordinances to protect water quality	Years 2-5	7 Lakes, Towns, KVCOG, Colby	7 Lakes, Towns	$5,000
B9	**Review tax assessment and plumbing records** in Belgrade, Mount Vernon, and Rome to determine: the #, %, and value of properties in the town, watershed and the SLZ; the #, %, and value of seasonal homes; and information about septic systems	Years 2-5	7 Lakes, Towns, KVCOG, Colby	7 Lakes, Towns	$5,000
B10	Develop a **watershed-wide P control ordinance** for all new development (including single family residential units, roads, and seasonal to year-round conversions)	Years 3-5	7 Lakes, Towns, Consultant	7 Lakes, Towns	$10,000
B11	Consider provisions for **3rd party site review**, and long-term	Years 3-5	7 Lakes, Towns, Consultant	7 Lakes, Towns	$2,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
	maintenance as a requirement for building permits				
B12	Encourage towns to offer **tax incentives for LakeSmart** properties and require re-certification every 5 years	Years 3-5	7 Lakes, BLA, Maine Lakes	7 Lakes, Towns	$3,000
Prevent New Sources of NPS (Future Development) Subtotal					**$95,000**

CLIMATE CHANGE

Watershed modeling estimates **an additional 28 – 139 kg P/yr in the north basin and 31 – 153 kg P/yr in the south basin from the watershed could be delivered to Long Pond with an increase in precipitation of 2-10%.** Climate change adaptation planning, such as upgrading infrastructure on roads (i.e., undersized culverts), infiltrating stormwater runoff on commercial and residential properties, planting buffers, and conserving undeveloped land are a few ways to counteract the effects of the anticipated increase in precipitation.

The following climate change activities should be factored into the future watershed planning activities. A detailed planning schedule, potential funding sources, and estimated costs for the seven actions is provided below.

PREVENT NEW SOURCES OF NPS (CLIMATE CHANGE)					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Climate Change					
B13	Form a Community Climate Change Committee and utilize Maine DEPs Adaptation Toolkit	Years 2-3	7 Lakes, BLA, Towns, Colby, KVCOG, KCSWCD, CCSP	Grants	$2,500
B14	Develop a Climate Change Action Plan utilizing the Maine Climate Council Guidance to prioritize community actions.	Year 3	7 Lakes, Towns, CCSP	Grants	$2,500
B15	Set up **automated precipitation monitoring** (e.g., automated rain gauges) to document occurrence and intensity of rainfall in the watershed	Years 2-10	7 Lakes, Colby	Grants	$6,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
B16	Utilize a **climate model** to anticipate effects of extreme events on lake water quality (e.g., heat, ice out, rainfall, drought)	Years 3-5	7 Lakes, Colby, Consultant	Grants	$5,000
B17	Host **climate change workshops** or webinars to provide information about ways landowners can adapt to climate change and help protect water quality	Years 3-5	7 Lakes, Colby, Consultant	Grants	$2,500
B18	**Identify problem culverts** at road/stream crossings that require upgrades.	Years 3-5	7 Lakes, Consultant, TNC	Grants, 7 Lakes	$5,000
B19	Work with watershed towns and Maine DOT to apply for grants to fund and implement **culvert upgrade projects**	Years 5-10	7 Lakes, Consultant, KVCOG	Grants, Towns, Maine DOT, Maine DEP	$200,000
Prevent New Sources of NPS Pollution (Climate Change) Subtotal					**$223,500**
Prevent New Sources of NPS Pollution Total					**$318,500**

EDUCATION, OUTREACH & COMMUNICATIONS

Public education and outreach is an important and necessary component of meeting the water quality goals set for in the Long Pond WBMP. Development of a comprehensive outreach strategy led by a steering committee consisting of watershed partners that are actively conducting outreach is needed in order to streamline outreach messaging and increase participation in watershed planning activities.

The Belgrade Lakes Association and 7 Lakes are the primary entities conducting public outreach in the watershed. BLA currently hosts an annual meeting each summer for all interested watershed residents, provides watershed updates on its website, and distributes an annual newsletter each summer. BLA does extensive outreach through their Stop Milfoil Campaign, among other outreach activities. 7 Lakes provides technical assistance to the association and the watershed towns to protect and preserve the natural resources within the watershed. 7 Lakes administers the YCC, the LakeSmart program for Great Pond and Long Pond, the Courtesy Boat Inspection (CBI) program, and provides public lectures and guided nature walks.

A detailed planning schedule, potential funding sources, and estimated costs for each of the 22 education and outreach actions is provided below.

EDUCATION, OUTREACH & COMMUNICATIONS ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
C. Education, Outreach & Communications					
General Outreach					
C1	Develop an outreach strategy/**communications committee** to get the word out to the community; meet annually to discuss plan objectives	Years 1-10	7 Lakes, BLA, interested stakeholders	7 Lakes, BLA	$10,000
C2	Develop and maintain a Long Pond WBMP **web page** for public to access information	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$10,000
C3	Keep partner **websites** updated regarding on-going monitoring efforts and NPS pollution projects	Years 1-10	7 Lakes, BLA, Towns	Towns, 7 Lakes, BLA	$5,000
C4	Prepare and distribute **press releases** and **newsletter articles** about watershed improvement activities, and grant projects, (goal 2/year)	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$5,000
C5	Provide **welcome packets** to new property owners with water quality educational materials	Years 2-10	7 Lakes, BLA	7 Lakes, BLA	$10,000
C6	Develop an **online video series** of short educational clips that can be viewed by the public (including climate change)	Years 3-10	Outreach Committee, Colby, 7 Lakes	Grants, 7 Lakes, BLA	$5,000
Targeted Outreach					
C7	Prepare a list of NPS sites on **town-owned properties** and work with towns on their annual budget planning (town beaches and roads)	Years 1-10	7 Lakes, BLA, Towns	7 Lakes, BLA	$10,000
C8	Prepare educational materials for **LakeSmart** program	Years 1-10	7 Lakes, BLA, Towns	7 Lakes, BLA, Grants	$10,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
C9	Prepare a list of NPS sites on **state roads** and meet with Maine DOT to discuss improvements	Years 1-10	7 Lakes, Maine DOT	7 Lakes	$2,000
C10	Meet with **homeowner associations** with known NPS sites to discuss results of the watershed survey and LakeSmart	Years 1-10	7 Lakes, Homeowner Associations	7 Lakes	$10,000
C11	Meet with **road associations** with documented NPS problems to determine interest in future 319 grant cost-sharing opportunities	Years 1-10	7 Lakes, Road Associations	7 Lakes	$10,000
C12	Conduct outreach to landowners/road associations to **promote use of bluestone surface gravel** for use on driveways and roads; identify roads where not currently used and provide **incentive** to switch over to new material	Years 1-10	7 Lakes, Road Associations, Landowners	7 Lakes	$5,000
C13	Design a **Buffer Campaign** with easy to follow guidance/recipes for installing effective shoreline buffers	Years 2-5	7 Lakes, BLA	7 Lakes, BLA, Grants	$10,000
C14	Meet with **business owners** in the Village District to discuss watershed survey results and possible funding opportunities	Years 3-5	7 Lakes, BLA	7 Lakes, BLA	$2,000
Workshops					
C15	Host annual **gravel road workshops** in the watershed working directly with road associations (goal 1/year)	Years 1-10	7 Lakes	7 Lakes, US EPA (319), Maine DEP	$5,000
C16	Coordinate with sister lake associations to host annual **regional buffer workshops** such as "Are you Buff Enough" (goal 1/year)	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$5,000
C17	Host annual **LakeSmart workshops** (goal 1/year)	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
C18	Host annual **Septic workshops** or **webinars** (goal 1/year)	Years 1-10	BLA	BLA	$5,000
C19	Host Ordinance workshop for landowners, developers, and realtors (goal 1 workshop)	Year 4	7 Lakes, BLA, Towns	7 Lakes	$2,500
Other					
C20	Consider developing a subcommittee to look at the **economic value of Long Pond** that can be used for public outreach	Years 3-10	Colby, 7 Lakes, KVCOG, BLA	7 Lakes, Colby	$5,000
C21	Continue **Lake Trust** meetings with area lake associations in upstream watersheds (East Pond, North Pond, Salmon Lake/McGrath Pond, and Great Pond) to reduce phosphorus inputs to their lakes and to share outreach BMPs	Years 1-10	7 Lakes, NPA, MP-SLA, EPA, BLA	7 Lakes	$10,000
C22	Work with **local realtors and towns** to track property transfers and subdivisions	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$10,000
Education, Outreach & Communications Total					**$151,500**

BUILDING LOCAL CAPACITY

7 Lakes, in cooperation with watershed partners, will oversee plan implementation, which will require funding the plan, meeting annually with project partners, and strengthening relationships within the community among other tasks described below. A detailed planning schedule, potential funding sources, and estimated costs for each of the 11 capacity building actions is provided below.

BUILD LOCAL CAPACITY
ACTION ITEMS & MANAGEMENT MEASURES

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D. Build Local Capacity					
Fundraising					
D1	Develop and maintain a **fundraising committee** to help implement the plan	Years 1-10	7 Lakes, BLA, Stakeholders	7 Lakes, BLA	$5,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D2	Apply for US EPA Clean Water Act Section 319 watershed implementation grants to address NPS sites ***Goal: 4 phases of 319 implementation projects***	Years 1, 3, 5, & 7	7 Lakes, Consultant	7 Lakes, BLA	$20,000
D3	Create a sustainable funding plan to pay for the cost of watershed implementation projects, erosion control program management, outreach and education, and long-term science and monitoring. ***Goal: $1,657,000 raised by 2032***	Years 2-10	7 Lakes, BLA	7 Lakes, BLA, Private Donors	$5,000
D4	Apply for other state, Federal or private foundation **grants** that support planning recommendations	Years 2-10	7 Lakes, Consultant	7 Lakes, BLA	$10,000
Steering Committee & Partnerships					
D5	Steering committee to **meet annually** to discuss action items and goals	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$5,000
D6	Reach out to new potential steering committee members including local businesses and realtors	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$1,000
D7	Continue working with watershed towns to strengthen **stakeholder relationships** and bolster community support for restoration efforts	Years 1-10	7 Lakes, BLA	7 Lakes, BLA	$1,000
D8	Coordinate with Colby, Bates, and other academic institutions regarding **ongoing scientific research projects** (e.g., NASA study, Gloeotrichia, e-DNA)	Years 1-10	7 Lakes, BLA, Colby, Bates, UMO	7 Lakes	$5,000
D9	Develop a comprehensive list of projects and an accessible **database** to track activities conducted by the numerous project partners that work in the watershed	Years 3-10	7 Lakes, BLA	7 Lakes, Grants	$10,000

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
D10	Meet with colleges and universities to **recruit students** for watershed management work	Years 3-10	7 Lakes, BLA	7 Lakes	$10,000
D11	Meet with area **landscaping companies** to develop programs to increase their capacity to do more erosion control work in the watershed	Years 3-10	7 Lakes, BLA	7 Lakes	$10,000
				Build Local Capacity Total	**$82,000**

8. Monitoring Activity, Frequency and Parameters

Maine water quality standards require Long Pond to have a stable or improving trophic state and be free of culturally induced algal blooms. Measuring the water quality of the lake is a necessary component of successful watershed planning because results can be used to evaluate the effectiveness of watershed management measures. If improvements in water clarity, phosphorus or other parameters are evident, or if water quality is stable, then planning objectives are being met, whereas if water quality gets worse, then additional management strategies may be needed.

FUTURE BASELINE MONITORING

An assessment of existing water quality monitoring data in Long Pond was completed as part of the water quality analysis (1970 - 2021). The steering committee determined that ongoing baseline monitoring efforts conducted by 7 Lakes, Colby, and Maine DEP should continue on Long Pond over the next 10 years in order to assess and track annual changes in water quality and the effects of the proposed work to reduce NPS pollution in the watershed.

Future monitoring actions are based on the current 7 Lakes monitoring program at Stations 1 and 2 which includes SDT, and DO and temperature profiles using a water quality sonde collected weekly from June-September and biweekly April-May, October-November; water samples for nutrients, and metals are collected on the same schedule using either a Van Dorn (during open water) or Kemmerer samples (under ice) every 2m from June-September, and every 4 m in April-May and October; water samples for phytoplankton are collected at 2 m depth; depending on ice conditions, sonde profiles and water samples are collected every 4 m January-March. Sediment samples are collected annually.

Action Plan & Management Measures		Schedule	Who	Potential Funding Sources	Estimated Cost (10 years)
E. Conduct Long-Term Monitoring & Assessment					
Baseline Lake Monitoring					
E1	Continue collecting **baseline water quality data** at least biweekly April - November to inform long-term management actions	Years 1-10	7 Lakes, Colby College, Maine DEP, Volunteers	7 Lakes, Private Donors, Grants	$150,000
E2	Track and document the presence and duration of ***Gloeotrichia*** and **metaphyton**	Years 1-10	7 Lakes, Colby, Volunteer Monitors	7 Lakes, BLA	$10,000
E3	Monitor **plankton** and **cyanobacteria** at stations 1 and 2 bi-weekly April-November using a flowcam	Years 1-10	7 Lakes, Colby	7 Lakes	$10,000
E4	Monitor the extent of **anoxia** at the bottom of the lake and at intermediate depths; maintain trend analyses	Years 1-10	7 Lakes, Colby	7 Lakes, Colby	$10,000
E5	Monitor and assess the **metalimnetic oxygen minimum** in Long Pond South to understand its origins and impact	Years 1-10	7 Lakes, Colby	7 Lakes, Colby	$10,000
E6	Conduct **winter sampling** for DO/Temp and P samples during ice-on	Years 1-10	7 Lakes, Colby	7 Lakes, Colby	$10,000
				Baseline Monitoring Subtotal	**$200,000**

7 Lakes will continue to work with project partners including BLA, Colby College, LSM volunteer water quality monitors, and Maine DEP to conduct long-term water quality monitoring at Long Pond, and to analyze the results of this data to inform future watershed management planning and assessment.

INTERNAL LOADING

Although internal loading is not currently considered a problem in Long Pond, analyzing the lake's sediments will help to illustrate the role that internal P loading may have on water quality in the future. The recommendations below will provide a better understanding of internal loading in Long Pond, and how it may change over the course of the 10-year plan.

INTERNAL LOADING ACTION ITEMS & MANAGEMENT MEASURES:					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Internal Loading					
E7	Review and report annual water quality data **and internal loading trends** to the steering committee, BLA, and other stakeholders: a) anoxic factor, b) water clarity, c) total phosphorus, d) phytoplankton community structure	Years 1-10	7 Lakes	7 Lakes, Colby	$10,000
E8	Analyze existing Colby **Long Pond sediment samples** and provide results to project partners	Years 2-4	Colby, 7 Lakes	7 Lakes, Colby	$10,000
				Internal Loading Subtotal	**$ 20,000**

SEPTIC SYSTEMS

More information is needed about the impact of septic systems on the water quality of Long Pond. A database of septic systems in the watershed will allow targeting of older, at-risk septic systems for improvement and help to catalog and reduce the negative impacts that septic systems may be having on the lake.

SEPTIC SYSTEMS ACTION ITEMS & MANAGEMENT MEASURES:					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Septic Systems					
E9	Compile town and state septic records, and create a septic database	Years 2-4	7 Lakes	Grants, BLA, 7 Lakes	$5,000
E10	Conduct a septic survey prioritizing high-risk systems (e.g., older systems, vulnerable soils)	Years 3-5	7 Lakes	Grants, BLA, 7 Lakes	$5,000
				Septic Systems Subtotal	**$ 10,000**

NPS POLLUTION

Additional NPS assessments following the 2020 Watershed Survey can be beneficial for preventing new sources of NPS from getting into the lake as well as protecting water quality and preventing the need for significant monetary investment to address internal loading.. The actions below will track NPS pollution in the watershed over the next 10 years.

NPS ASSESSMENTS ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
NPS Pollution					
E11	Set up **NPS Site Tracker** & update annually	Ongoing	7 Lakes	US EPA (319), 7 Lakes	$10,000
E12	Conduct **spring site visits to roads and other sites** with known issues in spring that did not make the 2020 NPS site list	Year 1	7 Lakes	7 Lakes	$10,000
E13	Conduct an informal watershed survey for **new NPS sites** 5 and 10 years after initial survey	Years 3 and 8	7 Lakes, BLA	7 Lakes, BLA, grants	$10,000
E14	Update 2010/2011 GIS-based **shoreline photos** and share with towns to assist with compliance in the shoreland zone; include documentation of buffer quality.	Years 2 and 7	Colby, 7 Lakes	7 Lakes, Colby	$10,000
				NPS Pollution Subtotal	**$40,000**

STREAM MONITORING

Long Pond receives its largest volume of inflow from the indirect drainage of Great Pond as well as several prominent perennial streams in the direct, and smaller indirect watersheds of Long Pond including Ingham Stream, Beaver Brook, Stony Brook, and Whittier Brook as well as numerous intermittent streams and drainages. All of these tributaries have the potential to deliver stormwater runoff from roads and development.

Currently, there is no reliable or consistent monitoring data available for these tributaries. Therefore, a significant degree of uncertainty exists regarding phosphorus loading from upstream drainages. Documenting in-stream phosphorus concentrations in streams that drain to Long Pond, and most importantly, from Great Pond will help inform future watershed planning in these drainages by determining to what extent runoff from streams plays a role in the phosphorus equation. Observed data can be incorporated into modelled predictions to better inform current watershed modeling.

Stream monitoring is recommended and should occur over a time frame of at least three years to develop a baseline phosphorus concentration for each tributary. Any future stream monitoring and assessment programs should:

STREAM MONITORING ACTION ITEMS & MANAGEMENT MEASURES					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Stream Monitoring					
E15	Develop a strategic stream monitoring plan before collecting samples.	Year 1	7 Lakes, Colby	7 Lakes, Colby, BLA	$500
E16	Collect **water quality data at targeted stream outlets** to assess P inputs; consider use of game cameras and stream gauges along with collection of samples from intermittent streams during storm events to determine P loading from select tributaries	Years 1-10	7 Lakes, Maine DEP, Volunteers	Grants, 7 Lakes, Colby	$30,000
E17	Train volunteer **"stream watchers"** to take pictures during storms or install game cameras; set up online repository for uploading photos; work with Maine DEP to train volunteers on how to collect storm samples	Years 3-10	Maine DEP, 7 Lakes, Volunteers	Grants, 7 Lakes, Colby	$3,000
E18	Deploy **automated samplers** to collect water samples and flow during storm events	Years 1 – 10	7 Lakes, Colby	Grants, 7 Lakes, BLA	$25,000
				Stream Monitoring Subtotal	**$58,500**

AQUATIC INVASIVE PLANTS

In a mesotrophic lake with a large littoral zone like Long Pond, keeping aquatic invasive plants (AIP) out of the lake is a high priority. The following actions should be taken to prevent the introduction of AIP in the lake:

AQUATIC INVASIVE PLANTS ACTION ITEMS & MANAGEMENT MEASURES:					
Action Plan & Management Measures		**Schedule**	**Who**	**Potential Funding Sources**	**Estimated Cost** (10 years)
Invasive Plant Monitoring					
E19	Participate in fundraising activities to **support programs that prevent the spread of milfoil** and other invasive aquatic plants (e.g., CBI, invasive plant surveys)	Years 1-10	7 Lakes, BLA	7 Lakes, BLA, DEP, Towns	$40,000
E20	Recruit and train volunteers to survey the littoral zone for invasive aquatic plants	Years 1-10	7 Lakes, BLA, LSM, DEP	7 Lakes, BLA, Volunteers	n/a
Invasive Aquatic Plants Monitoring Subtotal					**$40,000**
All Long-Term Monitoring & Assessment Total					**$368,500**

9. Measurable Milestones, Indicators & Benchmarks

The following section provides a list of interim, measurable milestones to document progress in implementing management strategies outlined in the action plan (Section 8). These milestones are designed to help keep project partners on schedule. Additional criteria are outlined to measure the effectiveness of the plan by documenting loading reductions and changes in water quality over time thus providing the means by which the steering committee can reflect on how well implementation efforts are working to reach established goals.

Photo Credit: 7 Lakes Alliance

Environmental, social, and programmatic indicators and proposed benchmarks represent short-term (1-2 years), mid-term (3-5 years), and long-term (6-10 years) targets for improving the water quality in Long Pond. The steering committee will review the criteria for each milestone annually to determine if progress is being made, and then determine if the watershed plan needs to be revised if targets are not being met. This may include updating proposed management practices and the loading analysis, and/or reassessing the time it takes for phosphorus concentrations to respond to watershed management including actions for reducing P in Great Pond which contributes a significant portion of the P load to Long Pond. The relatively small P reductions recommended in this plan may not be easily detected by annual monitoring and is not expected to result in large observable changes in lake trophic state, but rather to **ensure a stable or improving trophic state in the face of threats from existing and future development in the watershed and climate change.**

Environmental Milestones are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. Table 14 outlines the water quality benchmarks, and interim targets for improving the water quality of Long Pond over the next 10 years.

Social Milestones measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvements. Table 15 outlines the social indicators, benchmarks, and interim targets for the Long Pond WBMP.

Programmatic Milestones are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. Table 16 outlines the programmatic indicators, benchmarks, and interim targets for the Long Pond WBMP.

Table 14. *Water quality benchmarks and interim targets for Long Pond.*

Environmental Milestones			
Water Quality Benchmarks	***Interim Targets****		
	Years 1-2	*Years 3-5*	*Years 6-10*
a) Phosphorus loading reductions from external phosphorus (north basin) **Current:** 1,463 kg/yr **Goal:** 1,377 kg P/yr (reduce by 86 kg P/yr)	1,445 kg/yr *(▼ 18 kg/yr)*	1,421 kg/yr *(▼ 42 kg/yr)*	1,377 kg/yr *(▼ 86 kg/yr)*
b) Phosphorus loading reductions from external phosphorus sources (south basin) **Current:** 1,560 kg/yr **Goal:** 1,462 kg P/yr (reduce by 98 kg P/yr- 38 south basin, 60 indirect load from north basin)	1,550 kg/yr *(▼ 10 kg/yr)*	1,520 kg/yr *(▼ 40 kg/yr)*	1,462 kg/yr *(▼ 98 kg/yr)*
c) Decrease in average in-lake total phosphorus concentration (north basin) **Current:** 8.3 ppb **Goal:** 8.1 ppb	8.3 ppb *(▼ 0 ppb)*	8.2 ppb *(▼ 0.1 ppb)*	8.1 ppb *(▼ 0.2 ppb)*
d) Decrease in average in-lake total phosphorus concentration (south basin) **Current:** 8.3 ppb **Goal:** 7.9 ppb	8.3 ppb *(▼ 0 ppb)*	8.1 ppb *(▼ 0.2 ppb)*	7.9 ppb *(▼ 0.4 ppb)*

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2022-2023); Years 3-5 (2024-2027); Years 6-10 (2027-2032). (▲▼) arrows indicate a change in water quality up or down over the planning period.*

Table 15. Social indicators, benchmarks, and interim targets for Long Pond.

Social Milestones				
	Indicators	***Benchmarks & Interim Targets****		
		Years 1-2	*Years 3-5*	*Years 6-10*
a)	Number of landowner meetings organized (business owners, homeowner associations, etc.)	4 meetings	6 meetings *(10 total)*	10 meetings *(20 total)*
b)	Number of people viewing online video series	n/a	300 views	1000 views
c)	Number of educational workshops held (road associations, homeowner associations, gravel road workshop, buffer workshop, boat tours, etc.)	4 workshops	6 workshops *(10 total)*	10 workshops *(20 total)*
d)	Number of "welcome packets" distributed to new property owners in the watershed	10 packets	20 packets	40 packets
e)	Number of homeowners installing buffers through the Buffer Initiative **Goal:** 50 new or expanded shoreline buffers	10 sites	15 sites *(25 sites total)*	25 sites *(50 total)*
f)	Number of LakeSmart site visits and new landowners participating (cumulative) **Goal:** 25% of landowners participating	15% of all shoreline properties	20% of all shoreline properties	25% of all shoreline properties
g)	Number of NPS sites addressed by property owners **Goal:** 141 low-impact sites	35 sites	50 sites *(85 total)*	56 sites *(141 total)*
h)	Number of landowners participating in septic system incentive program **Goal:** 20 evaluations, 10 septic designs, 5 upgrades	n/a	8 evaluations, 4 designs, 2 upgrades	20 evaluations, 10 designs, 5 upgrades
i)	Number of planning board/selectman meetings attended to strengthen town ordinances and relationships with town officials **Goal:** 2 meetings/town/yr	12 meetings *(12 total)*	18 meetings *(30 total)*	30 meetings *(60 total)*
j)	Pollutant load reductions from Great Pond as a result of watershed projects (indirect load) **Goal:** 50 kg P/yr	10 kg P/yr	20 kg P/yr *(30 kg P total)*	20 kg P/yr *(50 kg P total)*
k)	Amount of additional hours for town CEOs/town/year	200	400	600

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2022-2023); Years 3-5 (2024-2027); Years 6-10 (2027-2032).*

Programmatic Milestones are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. Table 16 (below) outlines the programmatic indicators, benchmarks and interim targets for the Long Pond WBMP.

Table 16. *Programmatic indicators, benchmarks, and interim targets for Long Pond.*

Programmatic Milestones			
Indicators	***Benchmarks & Interim Targets****		
	(Years 1-2)	*(Years 3-5)*	*(Years 6-10)*
a) Number of NPS sites addressed. **Goal:** 26 high-impact, 91 medium-impact sites	24 sites	33 sites *(60 total)*	60 sites *(117 total)*
b) Number of steering committee meetings **Goal:** 1 meeting/year	2 meetings (2 total)	3 meetings *(5 total)*	5 meetings *(10 total)*
c) Amount of funding raised for water quality projects. **Goal:** $1,657,000	$350,000	$600,000 *($950,000 total)*	$707,000 *($1,657,000 total)*
d) Number of new ordinances passed that help protect water quality	0 ordinances	2 ordinances	4 ordinances

** Benchmarks are cumulative unless otherwise noted. Years 1-2 (2022-2023); Years 3-5 (2024-2027); Years 6-10 (2027-2032).*

POLLUTANT LOAD REDUCTIONS & COST ESTIMATES

The following pollutant load reductions and costs were estimated for the next 10-year planning cycle based on five primary planning objectives outlined in the action plan:

Table 17. Long Pond planning objectives, P load reduction targets & cost.

Planning Objective	Planning Action (2022-2032)	P Load Reduction Target	Cost
1	**Reduce the External P Load** (NPS sites, septic systems, LakeSmart, buffer campaign, upstream watersheds)	124 kg/yr	$736,200
2	**Prevent New Sources of NPS Pollution** (NPS sites, land conservation, ordinances, enforcement, climate change adaptation)	n/a	$318,500
3	**Education, Outreach & Communications** (Public meetings, targeted outreach, online videos, buffer campaign, LakeSmart, workshops, economic value, etc.)	n/a	$151,500
4	**Build Local Capacity** (Funding plan, steering committee, grant writing, relationship building- including Town government, contractors and scientists)	n/a	$82,000
5	**Long-Term Monitoring & Assessment** (Baseline monitoring, internal loading, septic systems, NPS pollution, stream monitoring, invasive plants)	n/a	$368,500
	TOTAL	**124 kg/yr**	**$1,656,700**

Actual pollutant load reductions will be documented as work is completed as outlined in this plan. This includes reductions for completed NPS sites to help demonstrate phosphorus and sediment load reductions as the result of BMP implementation. Pollutant loading reductions will be calculated using methods approved and recommended by Maine DEP and the US EPA and reported to Maine DEP for any work funded by 319 grants using an NPS site tracker.

10. Plan Oversight, Partner Roles, and Funding

PLAN OVERSIGHT

Implementation of a 10-year watershed plan cannot be accomplished without the help of a central organization to oversee the plan, and a diverse and dedicated group of project partners and the public to support the various aspects of the plan. The following organizations will be critical to the plan's success and are excellent candidates for the watershed plan steering committee. The committee will need to meet at least annually to update the action plan, to evaluate the plan's success, and to determine if the water quality goal is being met.

PARTNER ROLES

7 Lakes Alliance (7 Lakes) will oversee plan implementation and plan updates. 7 Lakes will provide 319 grant management and administration, serve on the steering committee, provide outreach and education opportunities in the watershed, manage the YCC, CBI, and milfoil removal programs, and be the general liaison between all watershed partners and technical advisors.

Belgrade Lakes Association (BLA) will serve on the project steering committee, provide project match as available, provide outreach and education opportunities in the watershed, and work with a fundraising committee to raise funds from outside sources to support the plan.

Colby College will continue as an important project partner providing ongoing research and lab support related to water quality in the watershed.

Kennebec County Soil & Water Conservation District (KCSWCD) may provide technical assistance, assistance for road projects, pollutant load reduction calculations, and sponsorship for grant funding.

Landowners & Road Associations will address NPS issues on their properties and provide a private source of matching funds by contributing to fundraising efforts and participating in watershed projects and LakeSmart.

Maine Department of Environmental Protection (Maine DEP) will provide watershed partners with ongoing guidance, technical assistance and resources, and the opportunity for financial assistance through grants including the US EPA's 319 grant program. Maine DEP will also serve on the steering committee.

Maine Lakes may provide support to the 7 Lakes LakeSmart Program Manager to evaluate and certify properties and provide LakeSmart signs for landowners meeting certification requirements.

Towns of Mount Vernon, Rome, and Belgrade will serve on the watershed steering committee, and may provide funding for water quality monitoring, match for watershed restoration projects, and support for the CBI and YCC programs. The towns will also play a key role in addressing any documented NPS sites on town roads and municipal/public property and providing training and education for municipal employees.

USDA/Natural Resources Conservation Service will provide education and outreach, technical and financial assistance to agricultural producers in the watershed.

US Environmental Protection Agency (US EPA) will provide guidance on grant programs particularly Clean Water Act Section 319, work plan guidance, and selected project funding, pending acceptability of grant proposals, final workplans and availability of federal funds.

ACTION PLAN IMPLEMENTATION & FUNDING

7 Lakes will develop and coordinate a public-private fundraising plan and will coordinate and implement the proposed action plan. Expected partners are 7 Lakes, BLA, local towns, Maine DEP, KCSWCD, landowners, road associations, businesses, and private donors.

Many of these partners have worked together for over 20 years. Accomplishments include developing and implementing the 2009 Long Pond Watershed-Based Management Plan, which included Great Pond; conducting four 319 implementation grants on Great Pond and Long Pond since 2009; and developing the 2021 Great Pond WBMP and the 2022 Long Pond WBMP. 7 Lakes, BLA, and local towns also have a long track record of working together on other large, successful programs including the STOP MILFOIL campaign (2012-present), the Youth Conservation Corps (1996-present), Courtesy Boat Inspections (2007-present), and other programs.

There are a number of opportunities for acquiring funding to support implementation of the watershed management plan. The list below contains a few of the better-known State and Federal funding options. Additional support from private foundation grants, local fundraising efforts, monetary contributions by participating landowners, and financial support from municipal partners will be needed to adequately fund this plan.

- **Land for Maine's Future Program** – Funding for land conservation that provides multiple public and natural resource benefits. For more information: https://www.maine.gov/dacf/lmf/
- **Maine DEP Courtesy Boat Inspection (CBI) Program Grants** – A cost-share program to help fund locally-supported CBI programs. For more information: https://www.maine.gov/dep/water/grants/invasive/index.html

- **Maine DEP Invasive Aquatic Plant Removal Grants** – Administered by Maine DEP to assist communities planning and managing removal of invasive aquatic plant infestations. For more information: https://www.maine.gov/dep/water/grants/invasive/index.html
- **Maine DEP Small Community Grant Program (SCG)** – Administered by Maine DEP, this program provides grants to Municipalities to help replace malfunctioning septic systems that are polluting a waterbody or causing a public nuisance. For more information: https://www.maine.gov/dep/water/grants/scgp.html
- **Maine DEP Stream Crossing Upgrade Grant Program** – A competitive grant program for the upgrade of municipal culverts and stream crossings that improve fish and wildlife habitats and improve community safety. For more information: https://www.maine.gov/dep/land/grants/stream-crossing-upgrade.html
- **Maine DOT's Municipal Partnership Initiative (MPI)** – This program funds projects of municipal interest on state infrastructure working with Maine DOT as a partner to develop, fund, and build the project. For more information: https://www.maine.gov/mdot/pga/
- **Maine Governor's Office of Policy Innovation and the Future (GOPIF)** – Two types of grants are offered including Community Action Grants to support projects that reduce energy use and costs and/or make their community more resilient to climate change effects, such as flooding, extreme weather, drought, and public health impacts. For more information: https://www.maine.gov/future/climate/community-resilience-partnership/grants
- **Maine Natural Resource Conservation Program (MNRCP)** – A cooperative program between Maine DEP and US Army Corps of Engineers, administered by The Nature Conservancy, funding the restoration, enhancement, preservation, and creation of wetland habitat. For more information: https://www.maine.gov/dep/land/nrpa/ILF_and_NRCP/index.html
- **US EPA Clean Water Act (Section 319) Watershed Nonpoint Source (NPS) Grant Program** – Administered by Maine DEP, 319 grants assist communities implementing a watershed-based management plan for waters named on Maine DEP's NPS Priority Watershed List. For more information: https://www.maine.gov/dep/water/grants/319.html
- **US EPA/Maine Clean Water State Revolving Fund (CWSRF)** – Provides financial assistance for a wide range of water infrastructure projects including control of nonpoint sources of pollution, and other water quality projects. For more information: https://www.epa.gov/cwsrf/learn-about-clean-water-state-revolving-fund-cwsrf
- **USDA/NRCS Financial Assistance** – NRCS offers voluntary programs to eligible landowners and agricultural producers to provide financial and technical assistance to help manage natural resources including financial assistance to help plan and implement conservation practices that address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest land: https://www.nrcs.usda.gov/wps/portal/nrcs/main/me/programs/financial/

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APPENDIX A. LONG POND NPS SITES

LONG POND NPS SITES

Impact of NPS Sites: The impact rating is an indicator of how much soil and phosphorus erodes into the lake from a given site. Factors such as slope, soil type, amount and severity of eroding soil, and buffer size are considered. Generally, low impact sites are those with limited transport of soil off-site, medium impact sites exhibit sediment transportation off-site, but the erosion does not reach high magnitude, and high impact sites are those with large areas of significant erosion and direct flow to water.

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
1-01	Directly into lake	Commercial	Surface Erosion - Sheet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation	Ditch- Armor with Stone; Vegetation- Add to Buffer, Reseed bare soil & thinning grass; Other- Clean catch basins on Rt 27 - between Dry Point Drive and Homestead Drive	Medium	Medium
1-02	Minimal Vegetation	State Road	Surface Erosion - Rill; Culvert - Unstable inlet/outlet	Culvert- Install Plunge Pool, Armor Inlet/Outlet; Other- The culvert is perched, a plunge pool is there but not large enough to prevent downstream erosion	Medium	Medium
1-03	Ditch	Private Road	Surface Erosion - Sheet; Soil - Winter Sand	Roads- Install Runoff Diverters-Waterbar, Reshape (Crown); Construction Site- Mulch; Other- Turn outs may be all it needs	Medium	High
1-04	Minimal Vegetation	State Road	Surface Erosion - Rill; Culvert - Unstable inlet/outlet; Road Shoulder Erosion - Rill; Soil - Bare	Culvert- Install Plunge Pool; Other- Perched culvert and existing plunge pool is filled with sediment - needs to be enlarged	Medium	High
1-05	Directly into lake	Private Road	Surface Erosion - Gully, Surface Erosion - Rill; Ditch - Gully Erosion, Ditch - Bank Failure, Ditch - Undersized	Ditch- Armor with Stone, Install Turnouts, Install Ditch, Reshape Ditch	High	High
1-06	Directly into lake	Private Road	Surface Erosion - Rill	Ditch- Install Ditch, Armor with Stone, Reshape Ditch, Install Turnouts; Roads- Reshape (Crown), Install Runoff Diverters-Waterbar; Other- Install ditch on left side driveway (looking up the road) and armor widen right side ditch	Medium	High
1-07	Directly into lake	Residential	Surface Erosion - Sheet, Surface Erosion - Rill	Roof Runoff- Infiltration Trench @ roof dripline	Low	Medium

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
1-08	Ditch	State Road	Shoreline - Undercut	Culvert- Install Plunge Pool, Replace; Ditch- Install Check Dams, Armor with Stone, Install Sediment Pools	Medium	Medium
1-09	Directly into lake	Residential	Surface Erosion - Sheet, Surface Erosion - Rill	Trails & Paths- Stabilize Foot Path, Erosion Control Mulch	Medium	Low
1-10	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Stabilize Foot Path, Erosion Control Mulch; Vegetation- No Raking; Other- Remove geotextile under path to promote growth	Low	Low
1A-01	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Lack of Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch, Stabilize Foot Path; Vegetation- Add to Buffer;	Low	Low
1A-02	Minimal Vegetation	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Stabilize Foot Path, Erosion Control Mulch	Low	Low
1A-03	Minimal Vegetation	Residential	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Define Foot Path, Stabilize Foot Path, Erosion Control Mulch; Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix, Mulch upper area of yard by house and define and stabilize footpaths	Low	Low
1A-04	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Unstable Access	Trails & Paths- Stabilize Foot Path; Other- Mulch/Erosion Control Mix, Landowner wants to put in stone steps on the path and maintain area as kayak launch. Mulching the launch area would cover bare soil.	Low	Low
1-11	Ditch	State Road	Soil - Delta in Stream/Lake		High	High
1-12	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Lack of Shoreline Vegetation, Shoreline - Erosion	Trails & Paths- Stabilize Foot Path, Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer, Reseed bare soil & thinning grass;	Low	Low
1-13	Ditch	Driveway	Surface Erosion - Gully; Culvert - Unstable inlet/outlet; Ditch - Gully Erosion; Soil - Bare	Culvert- Armor Inlet/Outlet; Ditch- Vegetate; Roads- Build Up, Reshape (Crown), Add gravel, Install Runoff Diverters-Waterbar; Trails & Paths- Stabilize Foot Path, Define Foot Path; Other- If not in use - fill and vegetate. If used then create a real path. ATV trail along SE edge of property needs stabilization and armoring.	High	Medium
1-14	Minimal Vegetation	Residential	Surface Erosion - Gully	Other- Rain Garden, Infiltration Trench, Septic Inspection,	Medium	Low

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
1-15	Ditch	Trail or Path	Surface Erosion - Rill; Culvert - Unstable inlet/outlet; Soil Bare; Erosion around culvert and trail itself	Culvert- Armor Inlet/Outlet; Trails & Paths- Erosion Control Mulch; Other- Stabilize trail with ECM, vegetate or gravel	Low	Low
2-01	Ditch	Construction Site	Surface Erosion - Sheet; Soil - Bare	Construction Site- Silt Fence/EC Berms, Seed/Hay, Mulch; Other- No sediment erosion control measures in place.	Low	Low
2-02	Ditch	Private Road	Road Shoulder Erosion - Sheet, Road Shoulder Erosion - Rill, Road Shoulder Erosion - Gully; Roadside Plow/Grader Berm	Roads- Remove Grader/Plow Berms, Build Up, Add gravel, Reshape (Crown); Other- Road drains strait to 225 doesn't reach drainage ditch	Medium	Medium
2-03	Ditch	Driveway	Surface Erosion - Rill; Culvert - Clogged, Culvert - Unstable inlet/outlet	Culvert- Armor Inlet/Outlet; Other- Driveway needs crown. Culvert needs armor.	Low	Medium
2-04	Ditch	State Road	Culvert - Unstable inlet/outlet, Culvert - Clogged; Ditch - Bank Failure	Culvert- Armor Inlet/Outlet;	Low	Low
2-05	Ditch	State Road	Surface Erosion - Gully; Road Shoulder Erosion - Gully	Roads- Vegetate Shoulder, Remove Grader/Plow Berms; Other- Vegetate shoulder where pavement ends	Medium	Medium
2-06	Ditch	Driveway	Surface Erosion - Gully	Roads- Add gravel; Other- Needs lots of rock	Medium	Medium
2-07	Ditch	Commercial	Surface Erosion - Gully, Surface Erosion - Rill	Construction Site- Mulch, Seed/Hay, Silt Fence/EC Berms; Other- Vegetate slope ditch drains to stream	Medium	Low
2-08	Stream	Residential	Soil - Bare	Other- Mulch/Erosion Control Mix, Recently paved driveway and garage roof will erode soil quickly if it rains. Needs to be stabilized.	Medium	Low
3-1	Minimal Vegetation	Town Road	Road Shoulder Erosion - Gully	Other- Sink hole in road is eroding. Could cause collapse of bridge if not repaired.	Medium	High
3-2	Ditch	Town Road	Culvert - Unstable inlet/outlet, Culvert - Clogged	Culvert- Remove Clog, Armor Inlet/Outlet	Medium	Low

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
3-3	Ditch	Driveway	Surface Erosion - Rill, Surface Erosion - Gully, Surface Erosion - Sheet	Culvert- Enlarge, Remove Clog; Other- Driveway needs new gravel. Culvert shows evidence of clogging and flowing across driveway.	Medium	Medium
3-4	Minimal Vegetation	Driveway	Surface Erosion - Gully, Surface Erosion - Rill, Surface Erosion - Sheet	Other- Drainage ditch on east side of driveway is draining across drive in two places. Should have culvert installed.	Medium	Low
3-5	Directly into lake	Residential	Surface Erosion - Sheet, Surface Erosion - Rill	Trails & Paths- Stabilize Foot Path, Define Foot Path; Other- Mulch/Erosion Control Mix, Infiltration Trench, Install gravel along walkway between stairs. Install infiltration trench under roof eaves, divert flow to woods.	High	Medium
3-6	Directly into lake	Residential	Surface Erosion - Gully, Surface Erosion - Sheet, Surface Erosion - Rill; Soil - Bare, Soil - Delta in Stream/Lake; Shoreline - Inadequate Shoreline Vegetation, Shoreline - Erosion	Trails & Paths- Stabilize Foot Path, Erosion Control Mulch; Other- Shoreline area needs ECM with gravel driveway should be armored.	High	Medium
3-7	Minimal Vegetation	Residential		Other- Stabilized gravel shoulder of driveway is eroding. Shoulder needs stabilization. Driveway should be regraded to divert runoff into woods before getting to house. Maybe box culverts?	Medium	High
4-01	Stream	Private Road	Surface Erosion - Gully, Surface Erosion - Rill; Culvert - Unstable inlet/outlet, Culvert - Crushed Broken; Ditch - Gully Erosion, Ditch - Rill Erosion; Road Shoulder Erosion - Rill, Road Shoulder Erosion - Gully; Roadside Erosion - Gully; Roadside Plow/Grader Berm; Roof Runoff Erosion	Culvert- Install Plunge Pool, Armor Inlet/Outlet, Replace; Ditch- Reshape Ditch, Install Sediment Pools, Install Turnouts; Roads- Build Up, Remove Grader/Plow Berms, Reshape (Crown), Add gravel;	Medium	High
5-01	Directly into lake	Other			High	Medium
5-02	Directly into lake	Trail or Path	Surface Erosion - Rill	Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar),	High	Medium

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
5-03	Directly into lake	Trail or Path	Surface Erosion - Rill, Surface Erosion - Sheet	Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Infiltration Trench,	Medium	Medium
5-04	Directly into lake	Trail or Path	Surface Erosion - Sheet, Surface Erosion - Rill	Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar),	Low	Low
5-05	Directly into lake	Trail or Path	Surface Erosion - Rill, Surface Erosion - Gully; Soil - Bare	Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar),	Medium	Medium
5-06	Directly into lake	Trail or Path	Surface Erosion - Rill; Soil - Bare; Shoreline - Erosion	Trails & Paths- Install Runoff Diverter (waterbar), Infiltration Steps, Erosion Control Mulch; Other- Mulch/Erosion Control Mix,	High	Medium
5-07	Stream	Other			Low	Low
6-01	Ditch	Beach Access	Surface Erosion - Rill; Soil - Bare	Other- Stabilize beach parking lot with bluestone etc.	Low	Low
6-02	Directly into lake	Trail or Path	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Erosion Control Mulch, Stabilize Foot Path	Low	Low
6-03	Ditch	Private Road	Surface Erosion - Gully; Roadside Plow/Grader Berm; Roof Runoff Erosion	Ditch- Install Turnouts; Roads- Remove Grader/Plow Berms, Reshape (Crown), Add gravel	Medium	High
6-04	Ditch	Private Road	Surface Erosion - Rill; Ditch - Undersized; Roof Runoff Erosion	Culvert- Remove Clog; Ditch- Install Ditch, Install Check Dams, Reshape Ditch, Remove debris/sediment; Roads- Build Up; Other- Remove grader berm	Medium	Medium
6-05	Ditch	Private Road	Surface Erosion - Sheet; Road Shoulder Erosion - Sheet; Soil - Bare	Roads- Add gravel, Reshape (Crown), Install Runoff Diverters-Broad-based Dip; Other- Needs well compacted road surface	Low	Medium
6-06	Ditch	Private Road	Surface Erosion - Sheet; Ditch - Undersized; Road Shoulder Erosion - Sheet; Roadside Plow/Grader Berm; Roof Runoff Erosion	Ditch- Install Turnouts, Remove debris/sediment, Reshape Ditch, Install Sediment Pools; Roads- Remove Grader/Plow Berms	Low	Medium
6-07	Ditch	Private Road	Culvert - Unstable inlet/outlet	Culvert- Armor Inlet/Outlet; Ditch- Vegetate	Low	Low

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
6-08	Directly into lake	Driveway	Surface Erosion - Sheet	Other- Stabilize driveway surface	Low	Low
6-09	Directly into lake	Boat Access	Surface Erosion - Sheet	Other- Install Runoff Diverter (waterbar), Extend pavement	Medium	High
6-10	Directly into lake	Beach Access		Trails & Paths- Stabilize Foot Path, Infiltration Steps, Install Runoff Diverter (waterbar), Erosion Control Mulch	Medium	Medium
7-01	Directly into lake	Residential	Shoreline - Undercut	Other- Rip Rap,	Low	High
7-02	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Undercut	Trails & Paths- Infiltration Steps; Vegetation- Establish Buffer, Add to Buffer; Other- Mulch/Erosion Control Mix, Rip Rap, Terrace, diversion swale	Medium	Medium
7-03	Directly into lake	Residential	Surface Erosion - Gully; Ditch - Undersized; Road Shoulder Erosion - Sheet; Soil - Bare; Roof Runoff Erosion	Ditch- Install Turnouts, Install Sediment Pools, Install Ditch; Roads- Install Catch Basin, Install Runoff Diverters-Waterbar; Construction Site- Mulch, Silt Fence/EC Berms; Trails & Paths- Define Foot Path, Install Runoff Diverter (waterbar); Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- Establish Buffer; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix,	Medium	High
7-04	Directly into lake	Driveway	Surface Erosion - Rill; Road Shoulder Erosion - Rill	Ditch- Install Ditch, Install Turnouts; Roads- Install Detention Basin, Reshape (Crown), Add gravel, Install Runoff Diverters-Waterbar	Medium	Medium
7-05	Directly into lake	Residential	Shoreline - Undercut, Shoreline - Erosion	Other- Rip Rap,	High	Medium
7-06	Ditch	Residential	Surface Erosion - Gully; Soil - Bare; Roof Runoff Erosion	Ditch- Armor with Stone, Install Ditch; Roads- Add gravel; Roof Runoff- Drywell @ gutter downspout; Other- Bluestone gravel for driveway.	Low	Medium
7-07	Ditch	Beach Access	Surface Erosion - Sheet; Culvert - Crushed Broken, Culvert - Unstable inlet/outlet; Ditch - Gully	Culvert- Armor Inlet/Outlet, Replace, Install Plunge Pool; Ditch- Reshape Ditch; Roads- Add gravel; Trails & Paths- Erosion Control Mulch; Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix, Common parking area needs	Medium	High

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
			Erosion; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	additional bluestone gravel. Culvert is 100 ft long and runs under parking area. Exposed dirt at beachfront.		
7-08	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Define Foot Path, Install Runoff Diverter (waterbar); Vegetation- Establish Buffer, Add to Buffer, Reseed bare soil & thinning grass; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix,	Low	Low
7-09	Directly into lake	Driveway	Surface Erosion - Rill	Roads- Reshape (Crown), Build Up; Other- Stabilize road shoulders	Low	Medium
7-10	Directly into lake	Residential	Surface Erosion - Gully, Surface Erosion - Sheet; Soil - Bare	Ditch- Install Ditch; Roads- Remove Grader/Plow Berms, Install Runoff Diverters-Waterbar; Trails & Paths- Define Foot Path; Vegetation- Establish Buffer, Add to Buffer; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix,	Medium	Medium
7-11	Ditch	Private Road	Surface Erosion - Rill; Culvert - Unstable inlet/outlet, Culvert - Crushed Broken, Culvert - Clogged, Culvert - Undersized; Ditch - Undersized, Ditch - Bank Failure, Ditch - Rill Erosion; Road Shoulder Erosion - Rill; Roadside Plow/Grader Berm	Culvert- Armor Inlet/Outlet, Replace, Install Culvert, Lengthen, Remove Clog, Install Plunge Pool, Enlarge; Ditch- Reshape Ditch, Remove debris/sediment, Install Turnouts, Armor with Stone, Install Ditch; Roads- Remove Grader/Plow Berms, Reshape (Crown), Add gravel, Vegetate Shoulder	High	High
7-12	Ditch	State Road	Culvert - Unstable inlet/outlet; Ditch - Bank Failure; Road Shoulder Erosion - Rill	Culvert- Armor Inlet/Outlet, Lengthen, Replace	Low	Medium
7D-01	Stream	Town Road	Surface Erosion - Rill; Road Shoulder Erosion - Rill	Ditch- Install Ditch, Install Turnouts; Roads- Reshape (Crown); Other- Reshape road and install ditch with turnout	Medium	High
7D-02	Stream	Town Road	Surface Erosion - Rill; Road Shoulder Erosion - Rill	Roads- Reshape (Crown), Add gravel, Build Up; Construction Site- Mulch; Other- Mulch/Erosion Control Mix, Reshape road surface, stabilize eroding bank	Medium	Medium
7D-03	Stream	State Road	Culvert - Unstable inlet/outlet; Ditch - Bank Failure, Ditch - Gully Erosion	Culvert- Armor Inlet/Outlet, Lengthen, Install Plunge Pool	Medium	High

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
7D-04	Stream	State Road	Surface Erosion - Rill; Ditch - Rill Erosion; Road Shoulder Erosion - Rill	Ditch- Install Ditch, Reshape Ditch, Install Turnouts	Medium	Medium
7D-05	Minimal Vegetation	State Road	Surface Erosion - Gully; Culvert - Unstable inlet/outlet; Road Shoulder Erosion - Gully	Culvert- Armor Inlet/Outlet; Ditch- Armor with Stone; Other- Road shoulder bank nears armoring	Medium	Medium
7D-06	Minimal Vegetation	Town Road	Surface Erosion - Gully; Ditch - Gully Erosion	Ditch- Armor with Stone, Reshape Ditch	Medium	Medium
8-01	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation, Shoreline - Erosion, Shoreline - Unstable Access	Trails & Paths- Erosion Control Mulch, Stabilize Foot Path; Vegetation- Add to Buffer, No Raking; Other- Reset lower water bar	Low	Low
8-02	Stream	Private Road	Surface Erosion - Gully; Culvert - Unstable inlet/outlet; Ditch - Gully Erosion	Culvert- Lengthen, Install Plunge Pool, Enlarge, Armor Inlet/Outlet; Ditch- Install Check Dams, Reshape Ditch	Medium	High
8-03	Minimal Vegetation	Beach Access	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation; Roof Runoff Erosion	Trails & Paths- Define Foot Path, Infiltration Steps, Erosion Control Mulch, Install Runoff Diverter (waterbar); Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- No Raking, Add to Buffer, Establish Buffer; Other- Install Runoff Diverter (waterbar),	Medium	Medium
8-04	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Vegetation- Add to Buffer, No Raking; Other- Mulch/Erosion Control Mix,	Low	Low
8-05	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation, Shoreline - Inadequate Shoreline Vegetation, Shoreline - Unstable Access	Trails & Paths- Erosion Control Mulch, Install Runoff Diverter (waterbar), Define Foot Path; Vegetation- Add to Buffer, No Raking, Establish Buffer; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Driveway runoff pooling near common area and could use diverter. No driveway site entered.	Medium	Medium
8-06	Minimal Vegetation	Driveway	Surface Erosion - Sheet; Soil - Bare	Roads- Reshape (Crown), Install Runoff Diverters-Rubber Razor, Install Runoff Diverters-Waterbar, Add gravel	Low	Low
8-07	Directly into lake	Residential	Surface Erosion - Rill; Soil - Bare; Shoreline - Lack of Shoreline Vegetation, Shoreline - Erosion,	Trails & Paths- Define Foot Path, Erosion Control Mulch, Infiltration Steps; Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- Establish Buffer, Add to Buffer, No Raking, Reseed bare soil & thinning grass; Other-	High	Medium

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
			Shoreline - Unstable Access; Roof Runoff Erosion	Mulch/Erosion Control Mix, Seed and hay for winter or first thing in spring.		
8A-01	Stream	Town Road	Surface Erosion - Sheet; Culvert - Unstable inlet/outlet, Culvert - Clogged	Culvert- Remove Clog, Armor Inlet/Outlet, Enlarge	Low	High
8A-02	Ditch	Town Road	Surface Erosion - Rill; Ditch - Undersized	Culvert- Armor Inlet/Outlet; Ditch- Vegetate, Install Ditch, Install Sediment Pools	Low	Medium
9-01	Stream	Construction Site	Surface Erosion - Gully; Road Shoulder Erosion - Sheet; Soil - Uncovered Pile, Soil - Bare	Construction Site- Silt Fence/EC Berms, Seed/Hay, Mulch; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Farm pond under construction needs erosion control	Low	Low
9-02	Ditch	Town Road	Ditch - Bank Failure; Road Shoulder Erosion - Gully; Soil - Bare	Ditch- Vegetate, Install Check Dams, Install Sediment Pools; Roads- Vegetate Shoulder; Other- Rip Rap, Undercut road edge, needs stabilization	Low	Medium
9-03	Ditch	Private Road	Ditch - Undersized; Road Shoulder Erosion - Gully	Ditch- Vegetate, Reshape Ditch	Medium	Medium
10-1	Stream	Town Road	Surface Erosion - Sheet; Culvert - Unstable inlet/outlet	Culvert- Armor Inlet/Outlet, Install Plunge Pool; Ditch- Install Sediment Pools	Low	Medium
10-02	Stream	Town Road	Surface Erosion - Sheet; Culvert - Unstable inlet/outlet, Culvert - Undersized	Culvert- Armor Inlet/Outlet, Enlarge	Low	Medium
10-03	Stream	Town Road	Surface Erosion - Sheet; Road Shoulder Erosion - Sheet; Roadside Plow/Grader Berm	Ditch- Vegetate, Armor with Stone; Roads- Remove Grader/Plow Berms, Build Up, Reshape (Crown)	Medium	Medium
10-04	Stream	Town Road	Culvert - Unstable inlet/outlet	Culvert- Armor Inlet/Outlet; Ditch- Reshape Ditch	Low	Low
11-1	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Vegetation- Reseed bare soil & thinning grass; Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar)	Low	Low
11-2	Stream	Private Road	Culvert - Unstable inlet/outlet; Ditch - Rill Erosion	Culvert- Armor Inlet/Outlet, Install Plunge Pool; Ditch- Remove debris/sediment, Vegetate, Armor with Stone; Other- Ditch erosion flows into cross culvert and into lake.	Medium	Medium

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
				Plunge pool at outlet is unstable and full of sediment. Temp driveway crosses through channel downstream of plunge pool		
11-3	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Other- Mulch/Erosion Control Mix,	Low	Low
11-4	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Stabilize Foot Path; Other- Mulch/Erosion Control Mix,	Low	Low
11-5	Minimal Vegetation	Town Road	Surface Erosion - Sheet; Ditch - Rill Erosion; Soil - Bare, Soil - Winter Sand	Culvert- Armor Inlet/Outlet; Ditch- Armor with Stone; Roads- Vegetate Shoulder; Other- Looks like ditch and plunge pool were recently cleaned out /excavated, but not stabilized. Exposed soil sediment delta into buffer but channel through woods that flows to lake. May need much larger plunge pool/ sed basin. Current size not adequate.	High	High
11-6	Directly into lake	Private Road	Culvert - Unstable inlet/outlet; Ditch - Rill Erosion; Road Shoulder Erosion - Rill; Soil - Bare, Soil - Winter Sand	Culvert- Armor Inlet/Outlet, Install Plunge Pool; Ditch- Vegetate, Armor with Stone, Install Check Dams; Other- Ditch to cross culvert with channel that flows to lake. Needs larger and armored plunge pool. Sed accumulating in channel through buffer area.	Medium	Medium
11-7	Directly into lake	Residential	Surface Erosion - Rill	Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix, Road and driveway runoff down steep driveway toward lake. LakeSmart property that just had construction completed on parking area. Needs to reinstall existing rubber razor and add 1-2 more. Request for YCC project to address driveway erosion.	Medium	Medium
11-8	Directly into lake	Driveway	Surface Erosion - Rill, Surface Erosion - Sheet; Culvert - Crushed Broken; Soil - Bare	Culvert- Replace; Roads- Install Runoff Diverters-Waterbar, Install Runoff Diverters-Rubber Razor, Install Runoff Diverters-Broad-based Dip, Reshape (Crown), Add gravel, Pave, Add recycled asphalt	Medium	High
11-9	Directly into lake	Private Road	Ditch - Rill Erosion, Ditch - Bank Failure; Road Shoulder Erosion - Sheet; Soil - Bare, Soil - Winter Sand	; Ditch- Armor with Stone, Install Sediment Pools, Vegetate, Reshape Ditch, Remove debris/sediment; Roads- Vegetate Shoulder; Other- Stream/drainage channel from slope above crosses road via culvert, very unstable on upstream side. Needs sed pool.	Medium	Medium
12-01	Ditch	Residential	Surface Erosion - Sheet; Soil - Bare; Roof Runoff Erosion	Roof Runoff- Drywell @ gutter downspout; Other- Mulch/Erosion Control Mix,	Low	Low

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
12-02	Minimal Vegetation	Residential	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix,	Low	Low
12-03	Directly into lake	Residential	Surface Erosion - Rill; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch; Other- Mulch/Erosion Control Mix,	Medium	Low
13A-01	Directly into lake	Commercial	Surface Erosion - Sheet; Road Shoulder Erosion - Sheet; Soil - Bare	Trails & Paths- Erosion Control Mulch, Stabilize Foot Path	Low	Low
13A-02	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Stabilize Foot Path, Install Runoff Diverter (waterbar), Erosion Control Mulch, Infiltration Steps	Medium	Low
13A-03	Stream	State Road	Surface Erosion - Gully; Culvert - Unstable inlet/outlet; Road Shoulder Erosion - Gully; Soil - Bare; Shoreline - Erosion	Culvert- Armor Inlet/Outlet; Ditch- Armor with Stone	High	Medium
13A-04	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Unstable Access	Trails & Paths- Define Foot Path, Install Runoff Diverter (waterbar), Erosion Control Mulch, Stabilize Foot Path	Medium	Low
13A-05	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Undercut, Shoreline - Erosion	Vegetation- Reseed bare soil & thinning grass, No Raking; Other- Rip Rap, Mulch/Erosion Control Mix, Shoreline has undercut lawn area; no lawn; bare soil needs mulch.	Low	Low
13A-06	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- No Raking;	Low	Low
13A-07	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer; Other- Multiple areas with bare soil roots exposed needs ECM	Medium	Low
13A-08	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Unstable Access, Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch, Infiltration Steps; Vegetation- Add to Buffer;	Low	Low
13A-09	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Unstable Access; Other; roadway circling camp in front lakeside of camp.	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer, Establish Buffer, Reseed bare soil & thinning grass	Low	Low

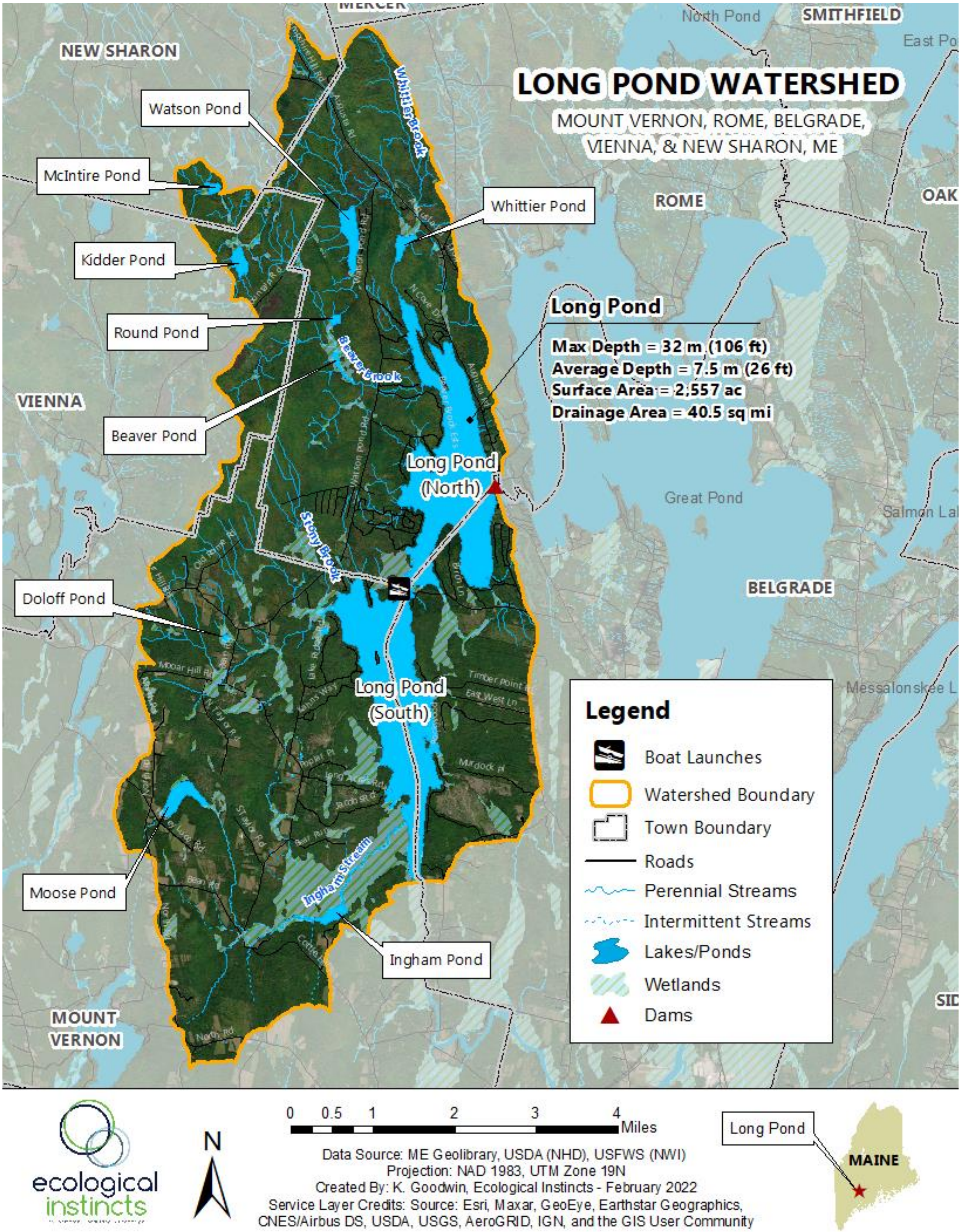
Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
13A-10	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix,	Low	Low
13A-11	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare	Trails & Paths- Define Foot Path; Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix,	Low	Low
13A-12	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Vegetation- Add to Buffer; Other- Rain Garden, Mulch/Erosion Control Mix,	Low	Low
13A-13	Minimal Vegetation	Residential	Surface Erosion - Sheet	Trails & Paths- Define Foot Path, Erosion Control Mulch; Other- Mulch/Erosion Control Mix,	Low	Low
13A-14	Directly into lake	Beach Access	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation, Shoreline - Erosion	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer, Establish Buffer; Other- Mulch/Erosion Control Mix, Water Retention Swales, Rain Garden,	Low	Low
13A-15	Minimal Vegetation	Beach Access	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation, Shoreline - Erosion	Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix,	Low	Low
13A-16	Stream	State Road	Culvert - Clogged	Culvert- Remove Clog	Low	Low
13A-17	Directly into lake	Residential	Surface Erosion - Rill; Soil - Bare	Trails & Paths- Infiltration Steps, Erosion Control Mulch, Install Runoff Diverter (waterbar); Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix,	High	Low
13A-18	Directly into lake	Residential	Surface Erosion - Gully; Soil - Bare, Soil - Winter Sand; Shoreline - Lack of Shoreline Vegetation, Shoreline - Unstable Access, Shoreline - Erosion; Roof Runoff Erosion	Trails & Paths- Define Foot Path, Install Runoff Diverter (waterbar), Erosion Control Mulch; Roof Runoff- Drywell @ gutter downspout, Infiltration Trench @ roof dripline; Vegetation- Establish Buffer; Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar), Water Retention Swales, Lakeside yard is all sand not sure what is needed	High	Low
13A-19	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch, Install Runoff Diverter (waterbar); Vegetation- Establish Buffer; Other- Mulch/Erosion Control Mix, Rain Garden,	Low	Low
13A-20	Directly into lake	Residential	Surface Erosion - Rill; Shoreline - Inadequate Shoreline Vegetation, Shoreline - Erosion, Shoreline - Unstable Access	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Establish Buffer; Other- Rain Garden, Mulch under picnic benches and over sand.	Medium	Low

Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
13A-21	Directly into lake	Residential	Surface Erosion - Rill; Shoreline - Erosion, Shoreline - Lack of Shoreline Vegetation	Trails & Paths- Define Foot Path, Erosion Control Mulch; Vegetation- Add to Buffer; Other- Continue with contained mulch to define area to dock.	Medium	Low
13B-01	Directly into lake	Municipal / Public	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Install Runoff Diverter (waterbar), Erosion Control Mulch; Vegetation- Add to Buffer; Other- Replenish crushed stone. Water bar below driveway	Low	Low
13B-02	Directly into lake	Residential	Surface Erosion - Rill; Culvert - Unstable inlet/outlet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation	Culvert- Armor Inlet/Outlet; Vegetation- Establish Buffer; Other- Culvert bottom rusted out-still functioning?	Low	Low
13B-03	Minimal Vegetation	Residential	Surface Erosion - Sheet; Soil - Bare; Roof Runoff Erosion	Trails & Paths- Erosion Control Mulch; Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- Add to Buffer, Reseed bare soil & thinning grass	Low	Low
13B-04	Minimal Vegetation	Private Road	Surface Erosion - Rill	Roads- Build Up, Reshape (Crown), Install Runoff Diverters-Waterbar; Vegetation- Add to Buffer; Other- Currently treated by buffer but potential to overwhelm	Low	Medium
13B-05	Minimal Vegetation	Commercial	Surface Erosion - Sheet; Culvert - Clogged	Culvert- Install Plunge Pool, Remove Clog; Roads- Add gravel, Install Runoff Diverters-Rubber Razor, Install Runoff Diverters-Waterbar; Vegetation- Add to Buffer	Low	Medium
13B-06	Directly into lake	Residential	Surface Erosion - Rill; Ditch - Undersized; Soil - Bare	Ditch- Install Check Dams, Reshape Ditch, Vegetate; Vegetation- Add to Buffer; Other- Water Retention Swales, Runoff from Sunset Grill and Main St exceeds ditch capacity. Blows out beach. Install new swale to break up flow. Redesign driveway to allow water to cross under (rock sandwich). Consider enlarging detention pond behind Sunset Grill.	Medium	High
13B-07	Ditch	Residential	Soil - Bare, Soil - Uncovered Pile; Other; Construction site. No ESC	Construction Site- Mulch, Seed/Hay, Silt Fence/EC Berms	Medium	Low
13B-08	Ditch	Town Road	Surface Erosion - Rill; Culvert - Unstable inlet/outlet; Ditch - Rill Erosion; Road Shoulder Erosion - Rill	Culvert- Lengthen, Enlarge, Install Plunge Pool, Armor Inlet/Outlet; Ditch- Install Check Dams, Vegetate; Other- Stabilize road shoulder with hard packing material. Stabilize ditch backslope.	Medium	Medium

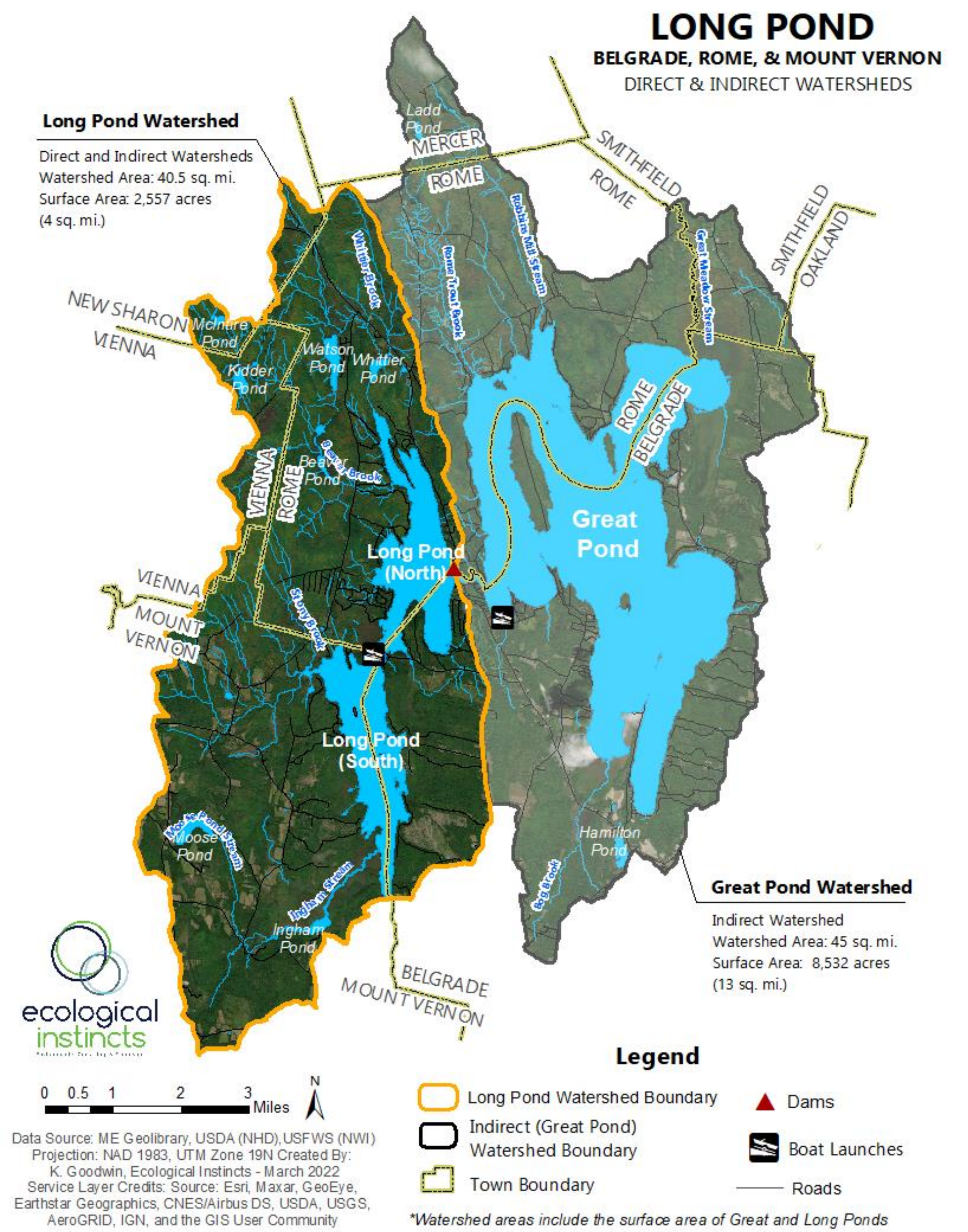
Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
13B-09	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Lack of Shoreline Vegetation	Trails & Paths- Stabilize Foot Path, Erosion Control Mulch, Define Foot Path, Install Runoff Diverter (waterbar) Vegetation- Establish Buffer; Other- Enlarge culvert outlet plunge pool next to beach access	Medium	Medium
13B-10	Directly into lake	Municipal / Public	Surface Erosion - Gully, Surface Erosion - Sheet; Soil - Bare	Roads- Install Runoff Diverters-Rubber Razor; Trails & Paths- Erosion Control Mulch; Vegetation- Add to Buffer; Other- Mulch/Erosion Control Mix, Install Runoff Diverter (waterbar), Clean out and enlarge basin at top of access	High	Medium
13B-11	Directly into lake	Residential	Surface Erosion - Rill; Soil - Bare; Shoreline - Lack of Shoreline Vegetation, Shoreline - Erosion; Roof Runoff Erosion	Trails & Paths- Install Runoff Diverter (waterbar); Roof Runoff- Infiltration Trench @ roof dripline; Vegetation- Establish Buffer; Other- Runoff diverter for driveway runoff into buffer	Low	Low
13B-12	Minimal Vegetation	Town Road	Surface Erosion - Rill; Culvert - Clogged, Culvert - Unstable inlet/outlet; Road Shoulder Erosion - Gully	Culvert- Armor Inlet/Outlet, Install Plunge Pool, Replace; Other- Stabilize road shoulder. Clean out plunge pool at culvert outlet.	Medium	Medium
13B-13	Minimal Vegetation	Residential	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation	Roof Runoff- Infiltration Trench @ roof dripline; Other- Install Runoff Diverter (waterbar), Mulch/Erosion Control Mix,	Low	Low
13B-14	Directly into lake	Residential	Surface Erosion - Sheet; Ditch - Sheet Erosion; Soil - Bare	Trails & Paths- Erosion Control Mulch	Low	Low
13B-15	Ditch	Driveway	Surface Erosion - Rill	Roads- Install Runoff Diverters-Open Top Culvert, Add gravel, Install Runoff Diverters-Broad-based Dip, Install Runoff Diverters-Waterbar	Low	Medium
13B-16	Directly into lake	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Erosion Control Mulch; Vegetation- Add to Buffer;	Low	Low
13B-17	Directly into lake	Residential	Surface Erosion - Sheet	Other- Mulch/Erosion Control Mix, Area has been well landscaped, just needs a little mulch maintenance	Low	Low
13B-18	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Erosion Control Mulch	Low	Low
13B-19	Ditch	Driveway	Culvert - Clogged	Culvert- Remove Clog	Low	Low

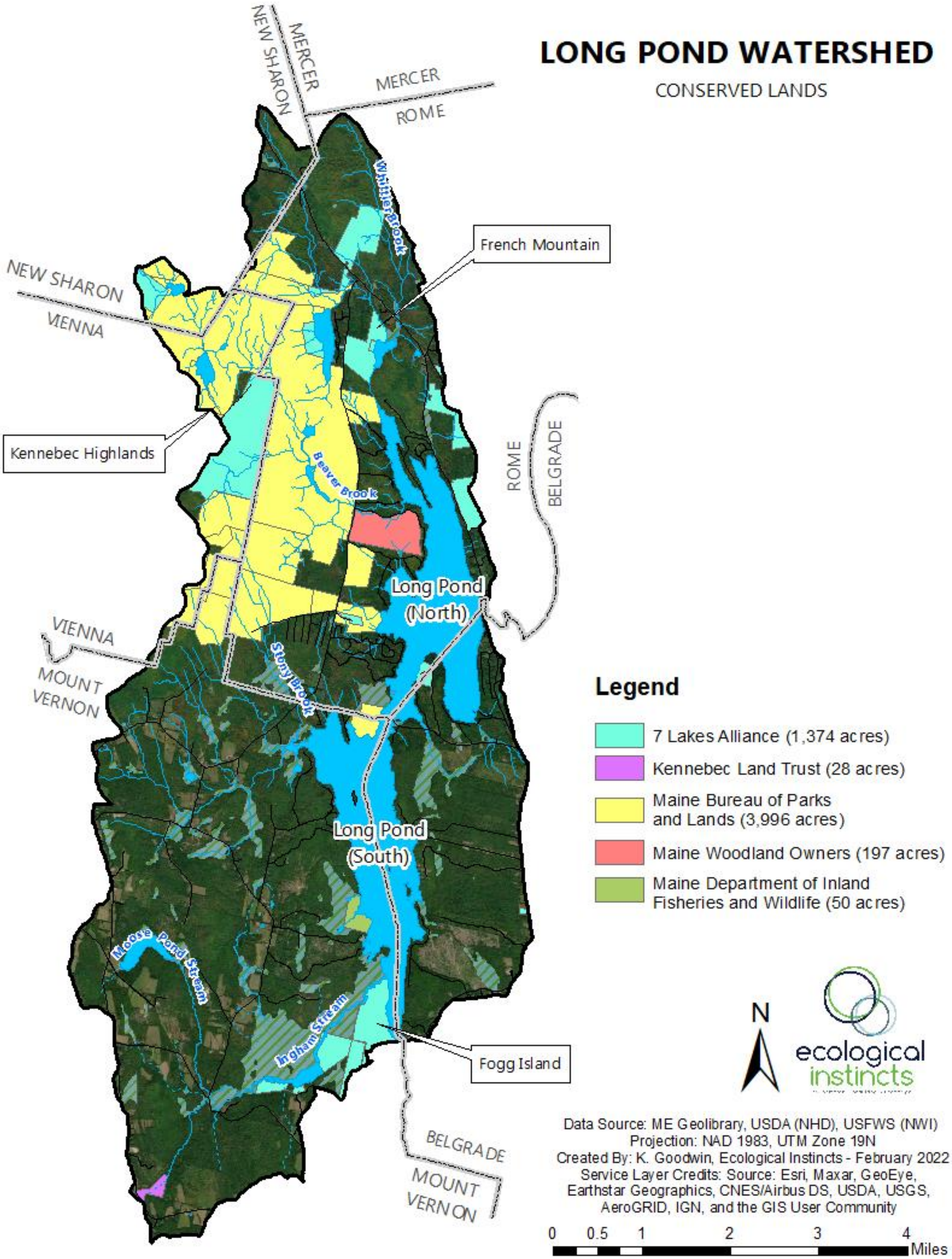
Site	Flow into lake via	Land Use	Problems	Recommendations	Impact	Cost
13B-20	Ditch	Driveway	Surface Erosion - Rill; Ditch - Rill Erosion	Roads- Install Runoff Diverters-Waterbar, Add recycled asphalt, Install Runoff Diverters-Rubber Razor	Medium	Medium
13B-21	Ditch	Town Road	Culvert - Clogged; Ditch - Sheet Erosion; Road Shoulder Erosion - Sheet	Culvert- Remove Clog	Low	Low
13B-22	Ditch	Driveway	Surface Erosion - Rill; Culvert - Clogged;	Culvert- Remove Clog; Roads- Add gravel, Reshape (Crown), Pave	Medium	Medium
13B-23	Ditch	Residential	Surface Erosion - Sheet; Other; Black pipe discharging to ditch on occasion, on property line	Other- Investigate source of discharge pipe	Low	Low
13B-24	Stream	State Road	Surface Erosion - Rill; Culvert - Clogged	Culvert- Remove Clog	Medium	Low
13B-25	Stream	Driveway	Surface Erosion - Rill	Roads- Reshape (Crown), Pave, Add gravel	Medium	Medium
13B-26	Minimal Vegetation	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Erosion Control Mulch; Vegetation- Add to Buffer, Reseed bare soil & thinning grass	Low	Low
13B-27	Directly into lake	Residential	Surface Erosion - Sheet; Shoreline - Inadequate Shoreline Vegetation	Vegetation- Establish Buffer	Low	Low
13B-28	Directly into lake	Residential	Surface Erosion - Sheet	Vegetation- Establish Buffer	Low	Low
13B-29	Minimal Vegetation	Residential	Surface Erosion - Sheet; Soil - Bare; Shoreline - Inadequate Shoreline Vegetation	Trails & Paths- Erosion Control Mulch; Other- Multiple access paths to water with bare soil - photo is representative	Low	Low

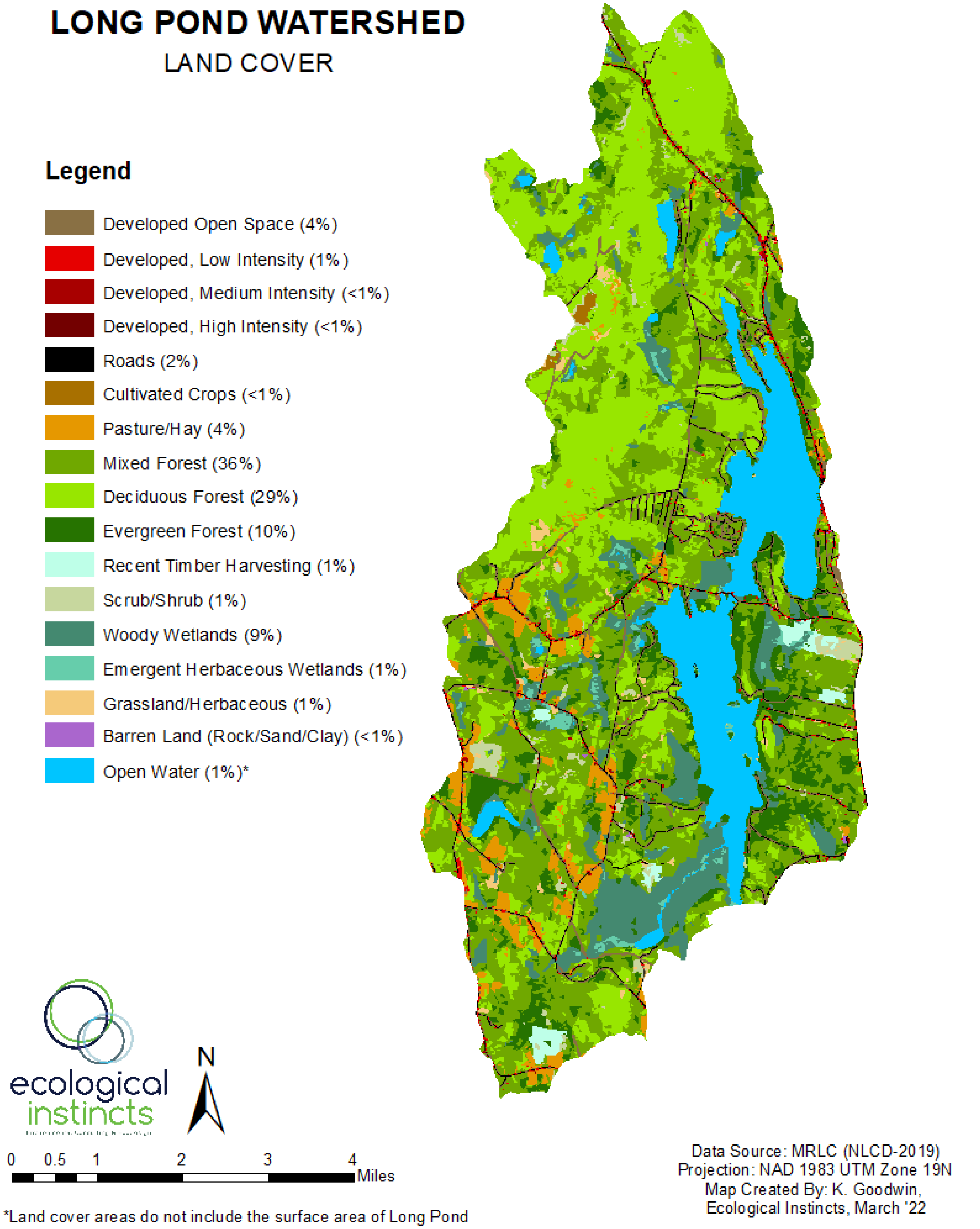
APPENDIX B. WATERSHED MAPS

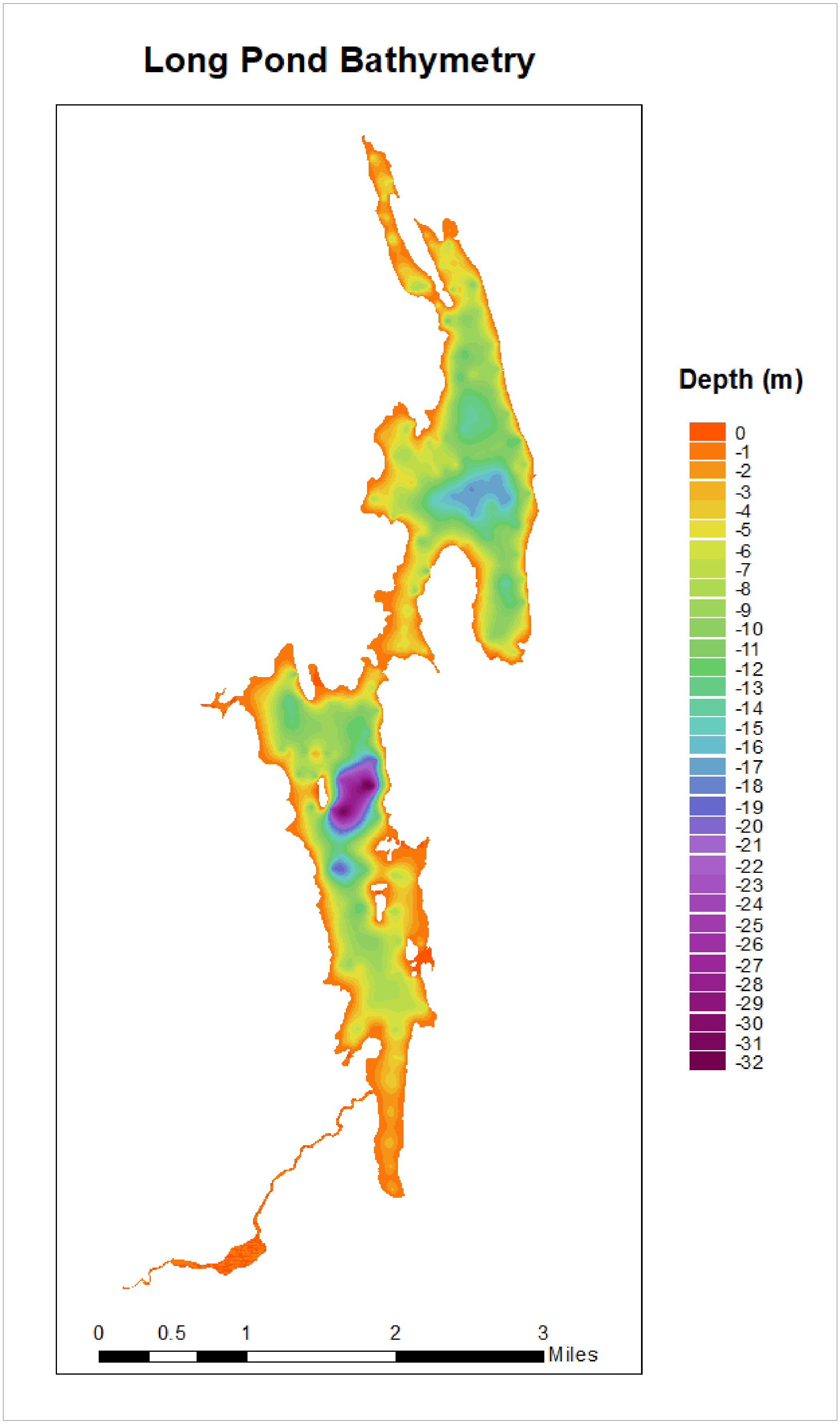


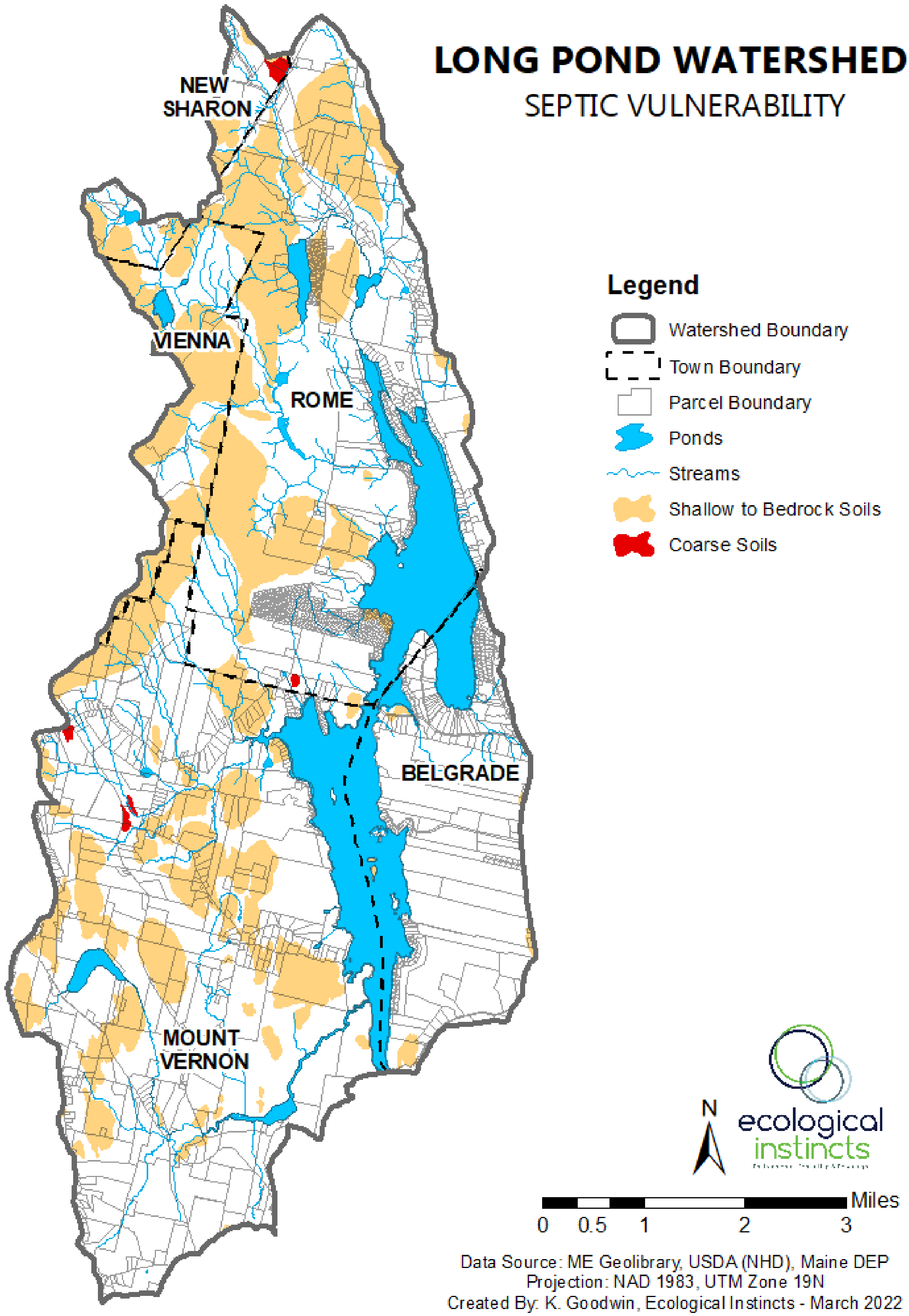
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - February 2022
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

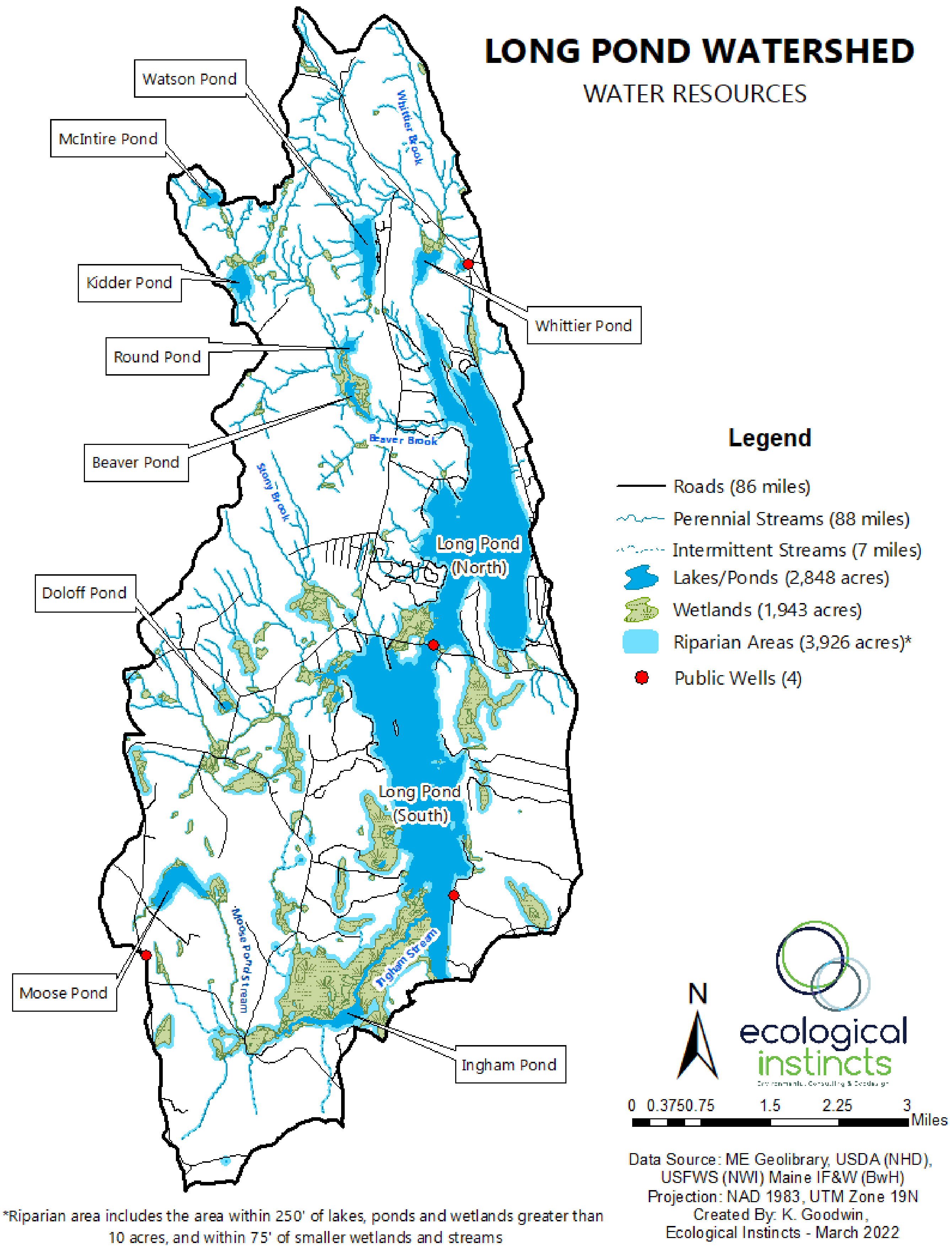

LONG POND
BELGRADE, ROME, & MOUNT VERNON
DIRECT & INDIRECT WATERSHEDS
Long Pond Watershed
Direct and Indirect Watersheds
Watershed Area: 40.5 sq. mi.
Surface Area: 2,557 acres
(4 sq. mi.)
Ladd Pond
MERCER
ROME
SMITHFIELD
ROME
SMITHFIELD
OAKLAND
NEW SHARON
VIENNA
McIntire Pond
Kidder Pond
Watson Pond
Whittier Pond
Whittier Brook
Rome Trout Brook
Robbins Mill Stream
Great Meadow Stream
ROME
BELGRADE
VIENNA
ROME
Beaver Pond
Beaver Brook
Great Pond
Long Pond (North)
VIENNA
MOUNT VERNON
Stony Brook
Long Pond (South)
Moose Pond
Moose Pond Stream
Ingham Stream
Ingham Pond
Hamilton Pond
Bog Brook
Great Pond Watershed
Indirect Watershed
Watershed Area: 45 sq. mi.
Surface Area: 8,532 acres
(13 sq. mi.)
BELGRADE
MOUNT VERNON
ecological instincts
0 0.5 1 2 3 Miles
N
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI)
Projection: NAD 1983, UTM Zone 19N Created By:
K. Goodwin, Ecological Instincts - March 2022
Service Layer Credits: Source: Esri, Maxar, GeoEye,
Earthstar Geographics, CNES/Airbus DS, USDA, USGS,
AeroGRID, IGN, and the GIS User Community
Legend
Long Pond Watershed Boundary
Indirect (Great Pond) Watershed Boundary
Town Boundary
Dams
Boat Launches
Roads
*Watershed areas include the surface area of Great and Long Ponds

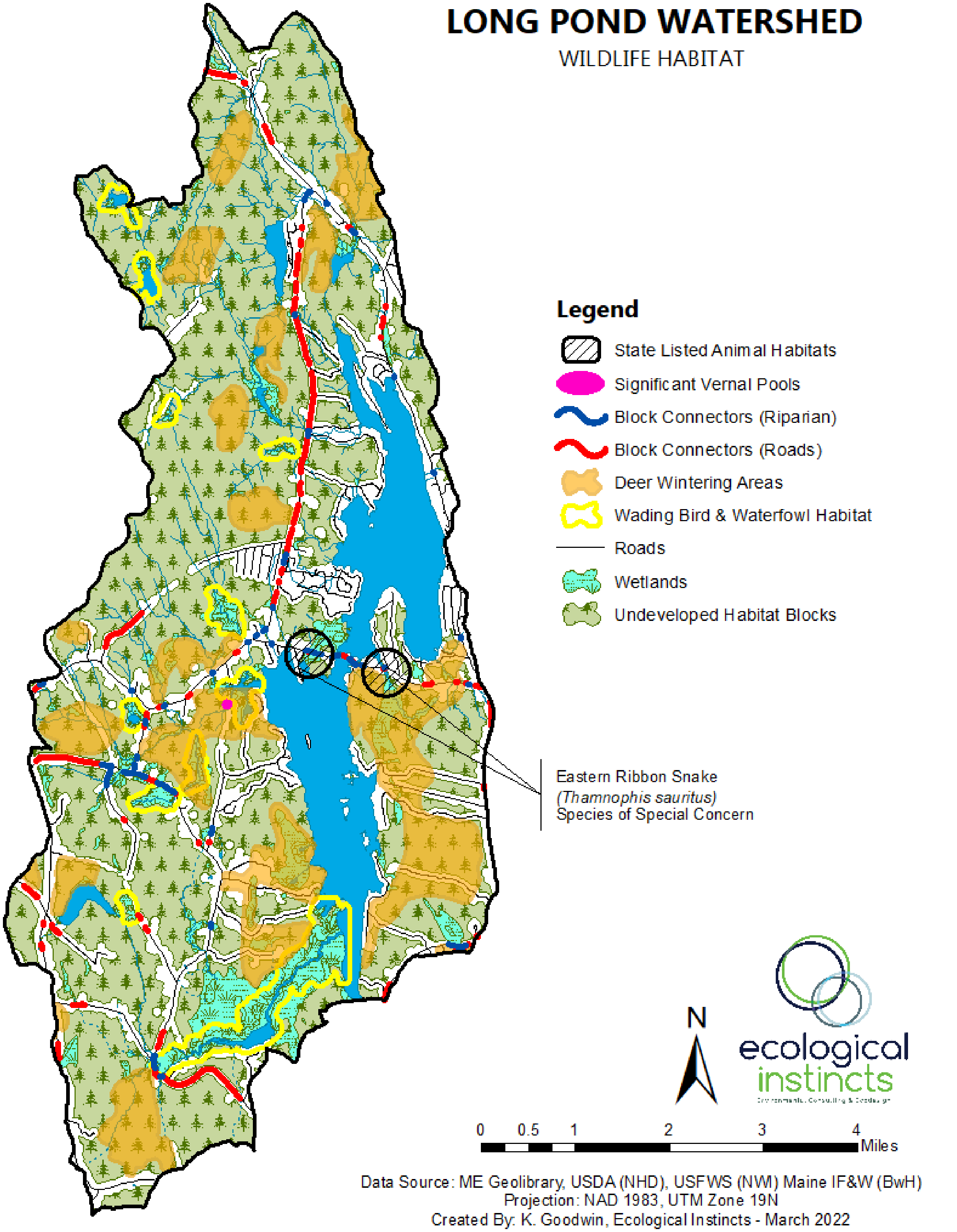

LONG POND WATERSHED
CONSERVED LANDS
NEW SHARON
MERCER
ROME
VIENNA
BELGRADE
MOUNT VERNON
French Mountain
Kennebec Highlands
Fogg Island
Long Pond (North)
Long Pond (South)
Whittier Brook
Beaver Brook
Stony Brook
Moose Pond Stream
Ingham Stream
Legend
7 Lakes Alliance (1,374 acres)
Kennebec Land Trust (28 acres)
Maine Bureau of Parks and Lands (3,996 acres)
Maine Woodland Owners (197 acres)
Maine Department of Inland Fisheries and Wildlife (50 acres)
N
ecological instincts
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - February 2022
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 0.5 1 2 3 4 Miles

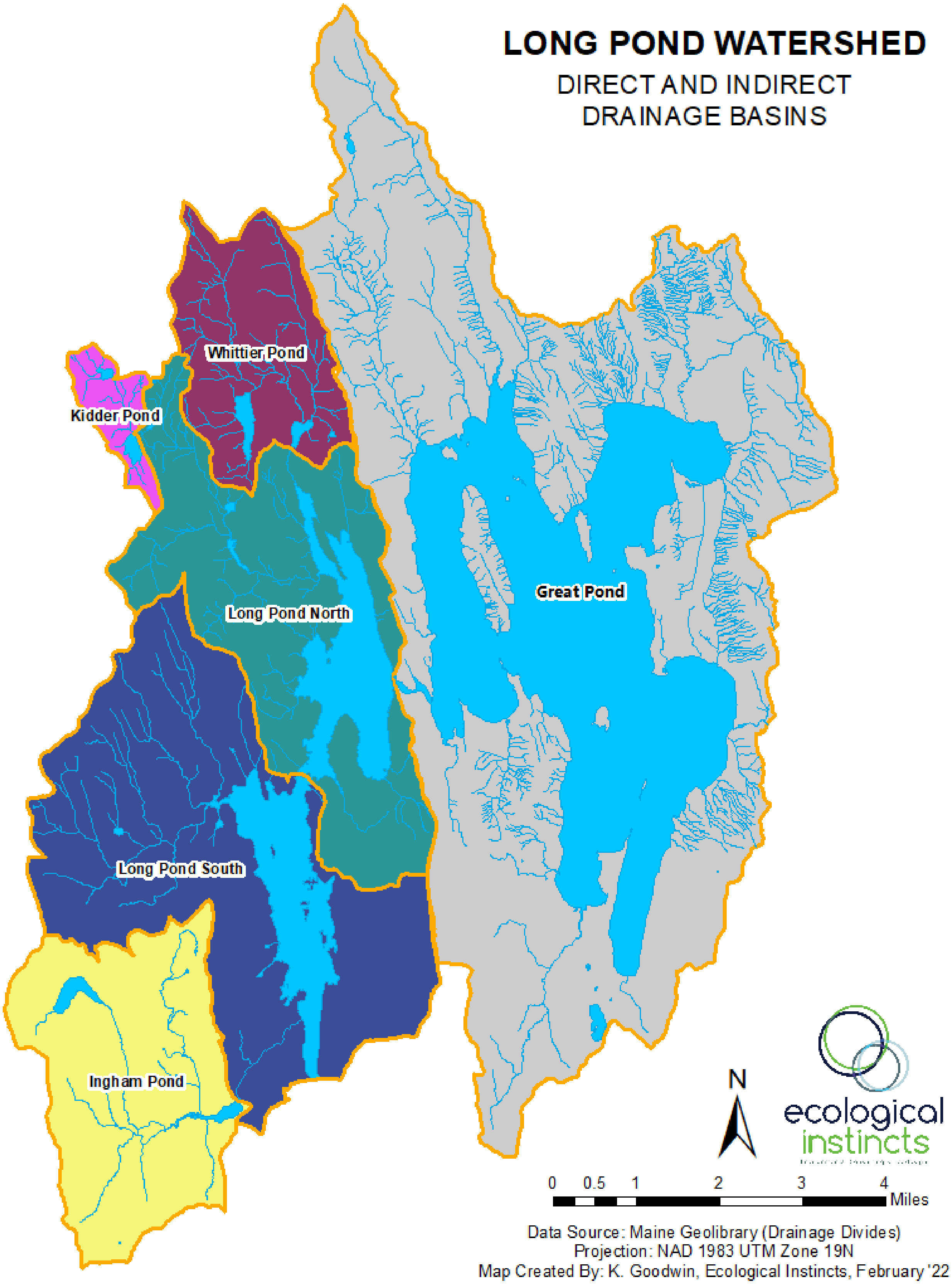

LONG POND WATERSHED
LAND COVER
Legend
Developed Open Space (4%)
Developed, Low Intensity (1%)
Developed, Medium Intensity (<1%)
Developed, High Intensity (<1%)
Roads (2%)
Cultivated Crops (<1%)
Pasture/Hay (4%)
Mixed Forest (36%)
Deciduous Forest (29%)
Evergreen Forest (10%)
Recent Timber Harvesting (1%)
Scrub/Shrub (1%)
Woody Wetlands (9%)
Emergent Herbaceous Wetlands (1%)
Grassland/Herbaceous (1%)
Barren Land (Rock/Sand/Clay) (<1%)
Open Water (1%)*
ecological instincts
N
0 0.5 1 2 3 4 Miles
*Land cover areas do not include the surface area of Long Pond
Data Source: MRLC (NLCD-2019)
Projection: NAD 1983 UTM Zone 19N
Map Created By: K. Goodwin,
Ecological Instincts, March '22


Long Pond Bathymetry
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
-31
-32
0
0.5
1
2
3
Miles


LONG POND WATERSHED
SEPTIC VULNERABILITY
NEW SHARON
VIENNA
ROME
BELGRADE
MOUNT VERNON
Legend
Watershed Boundary
Town Boundary
Parcel Boundary
Ponds
Streams
Shallow to Bedrock Soils
Coarse Soils
N
ecological instincts
0 0.5 1 2 3 Miles
Data Source: ME Geolibrary, USDA (NHD), Maine DEP
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - March 2022


LONG POND WATERSHED
WATER RESOURCES
Watson Pond
McIntire Pond
Kidder Pond
Round Pond
Beaver Pond
Doloff Pond
Moose Pond
Whittier Pond
Ingham Pond
Whittier Brook
Beaver Brook
Stony Brook
Long Pond (North)
Long Pond (South)
Moose Pond Stream
Ingham Stream
Legend
Roads (86 miles)
Perennial Streams (88 miles)
Intermittent Streams (7 miles)
Lakes/Ponds (2,848 acres)
Wetlands (1,943 acres)
Riparian Areas (3,926 acres)*
Public Wells (4)
N
ecological instincts
0 0.375 0.75 1.5 2.25 3 Miles
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI) Maine IF&W (BwH)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - March 2022
*Riparian area includes the area within 250' of lakes, ponds and wetlands greater than 10 acres, and within 75' of smaller wetlands and streams


LONG POND WATERSHED
WILDLIFE HABITAT
Legend
State Listed Animal Habitats
Significant Vernal Pools
Block Connectors (Riparian)
Block Connectors (Roads)
Deer Wintering Areas
Wading Bird & Waterfowl Habitat
Roads
Wetlands
Undeveloped Habitat Blocks
Eastern Ribbon Snake
(Thamnophis sauritus)
Species of Special Concern
N
ecological instincts
0 0.5 1 2 3 4
Miles
Data Source: ME Geolibrary, USDA (NHD), USFWS (NWI) Maine IF&W (BwH)
Projection: NAD 1983, UTM Zone 19N
Created By: K. Goodwin, Ecological Instincts - March 2022


LONG POND WATERSHED
DIRECT AND INDIRECT
DRAINAGE BASINS
Whittier Pond
Kidder Pond
Long Pond North
Great Pond
Long Pond South
Ingham Pond
N
ecological
instincts
0
0.5
1
2
3
4
Miles
Data Source: Maine Geolibrary (Drainage Divides)
Projection: NAD 1983 UTM Zone 19N
Map Created By: K. Goodwin, Ecological Instincts, February '22

APPENDIX C. STATISTICAL ANALYSIS OF 2015-2021 WATER QUALITY DATA

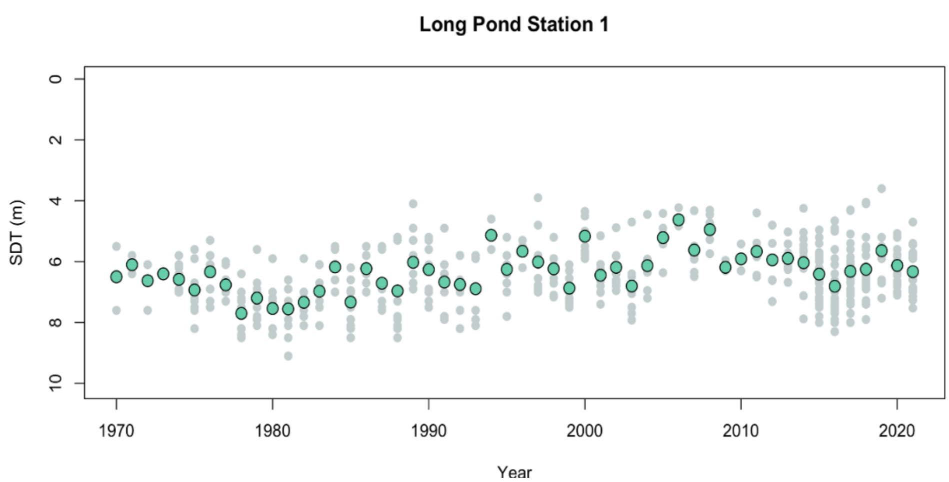
Long Pond Water Quality Summary Memo
Dr. Danielle Wain, Lake Science Director, 7 Lakes Alliance
March 2, 2022

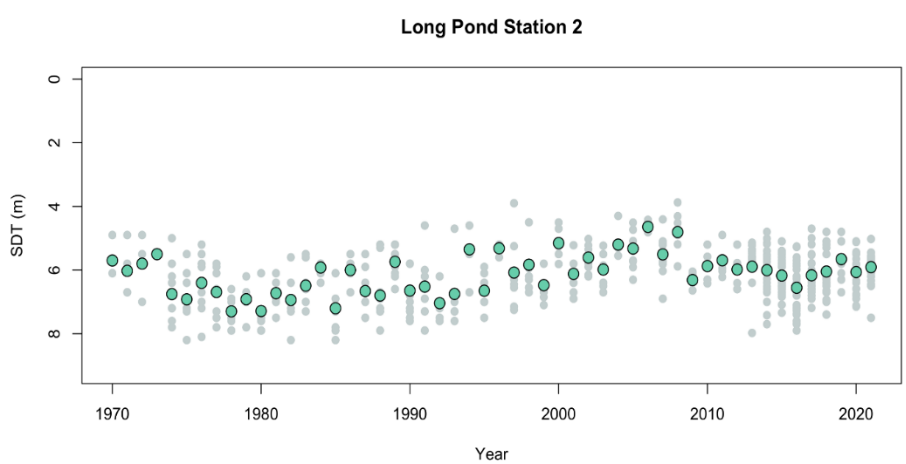
Secchi Trends

The data range for Secchi Disk Transparency (SDT) measurements in Long Pond is 1970-2021. Data from 1970 to 2021 was collected by certified lake monitors from Lake Stewards of (LSM) (formerly the Volunteer Lake Monitoring Program) and the Maine Dept. of Environmental Protection (DEP). From 2015-2020, LSM measurements on Long Pond were supplemented by the 7 Lakes Alliance and Colby College. For this analysis, all data from a given month and year was averaged together, and all months from that year were averaged to generate the annual average. A Mann-Kendall trend analysis was conducted on the full time series as well as the last 10 years to determine if there were any significant trends in the data.

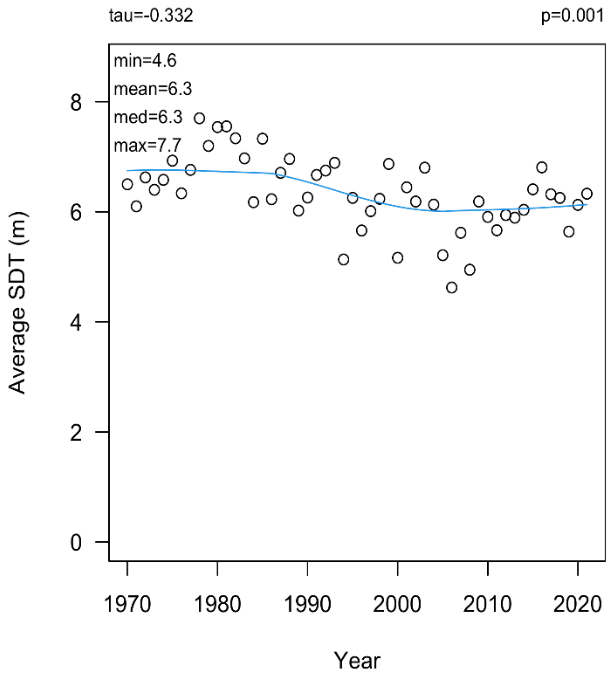
All data from both stations is shown below. For Station 1, the lowest water clarity on record was 3.6 m, observed in October 2019. The highest water clarity on record was 9.1 m, observed in June 1981. For Station 2, the lowest water clarity was 3.9 m observed in June 2008 and the highest water clarity was 8.2 m, observed in August 1975.

At both stations, **there is a weak but significant trend in SDT for the full time series and indicates a decrease in water clarity over time.** There has been no significant trend over the last 10 years, indicating the water clarity has stabilized.

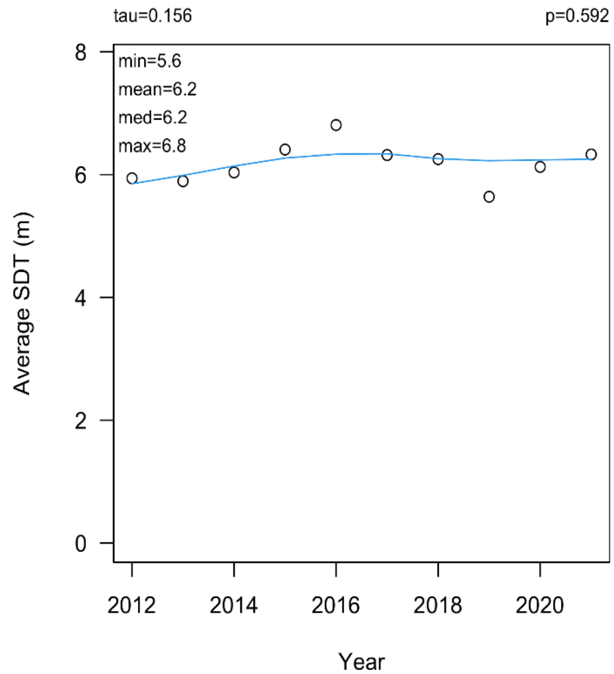




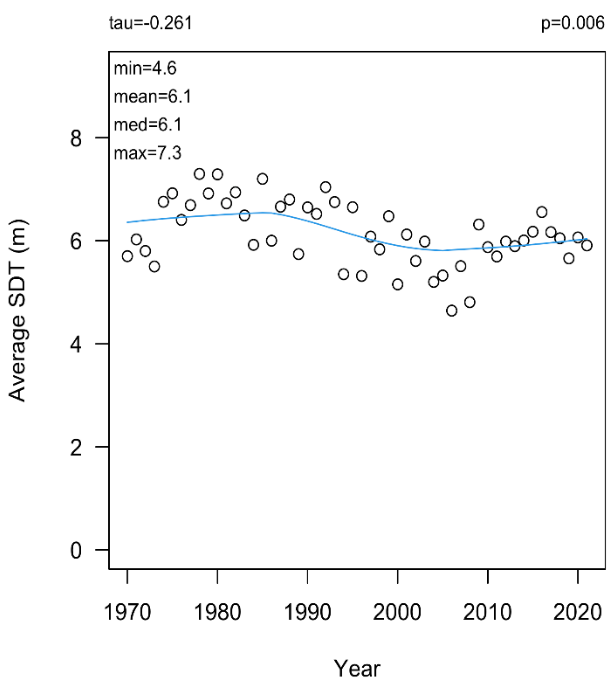
Long Pond (MIDAS 5272 - Station 1)



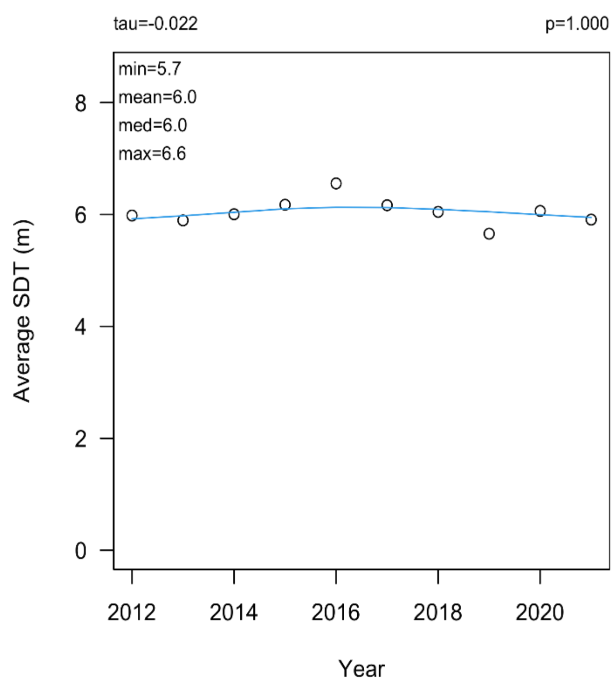
Long Pond (MIDAS 5272 - Station 1)



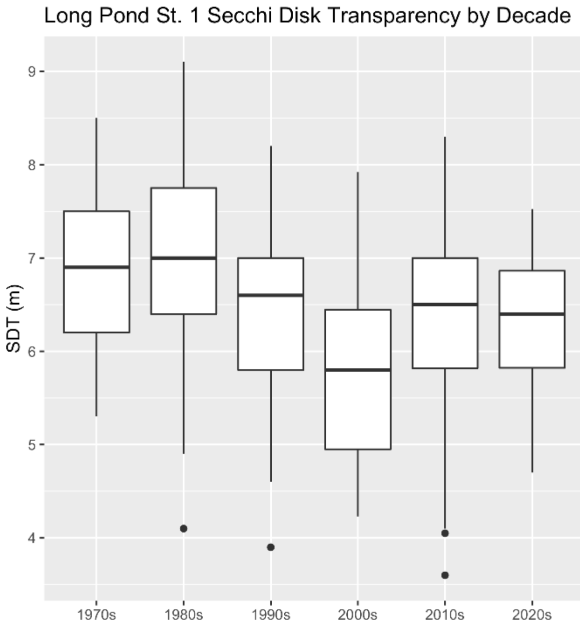
Long Pond (MIDAS 5272 - Station 2)

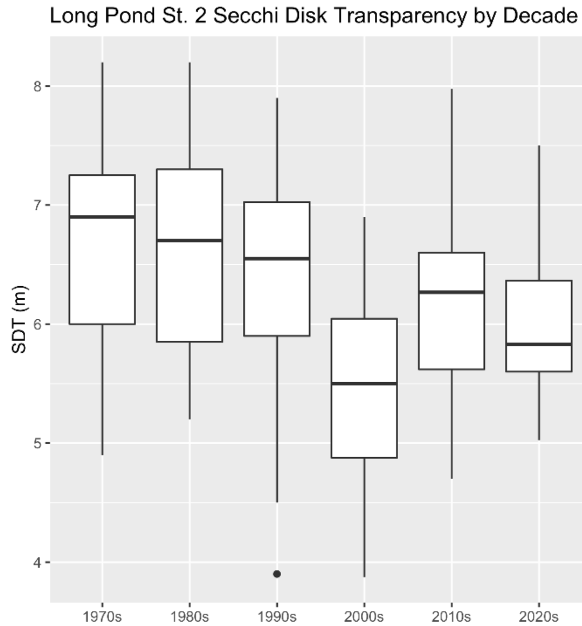


Long Pond (MIDAS 5272 - Station 2)



Decadal medians for both stations show the lowest SDT in the 2000s (the worst water clarity). While there was significant improvement in the 2010s, the 2020s have seen a slight worsening of water clarity. The best decade for Station 1 was the 19980s and the best decade for Station 2 was the 1970s.

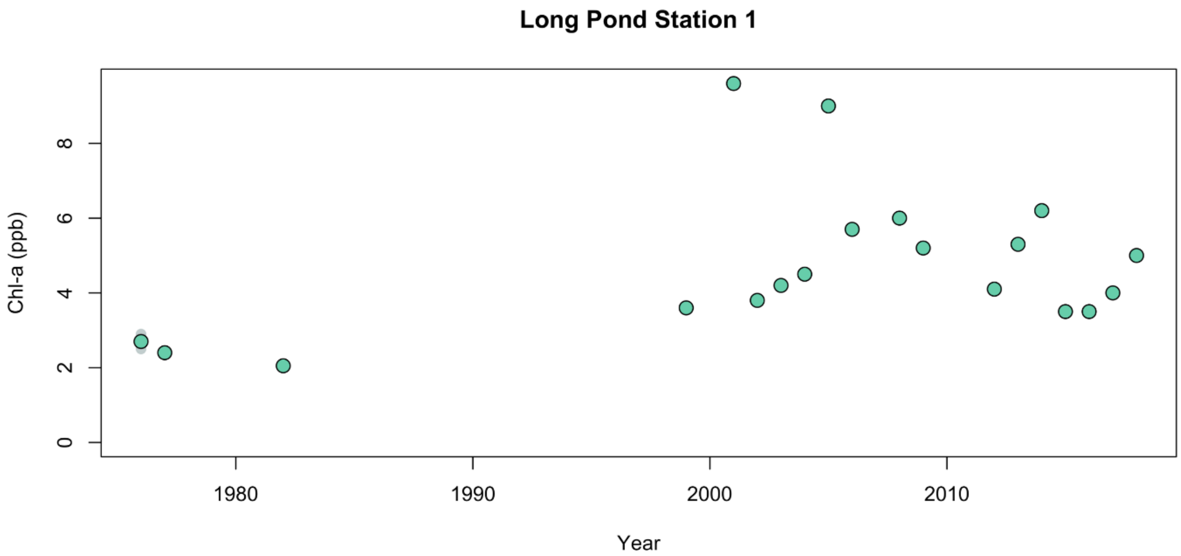


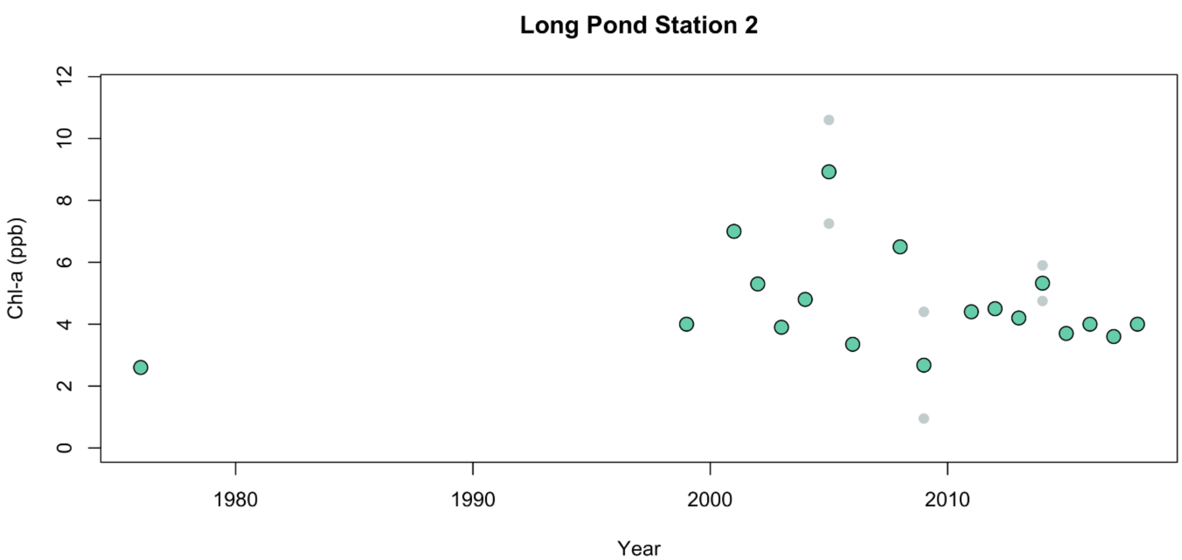


Chlorophyll Trends

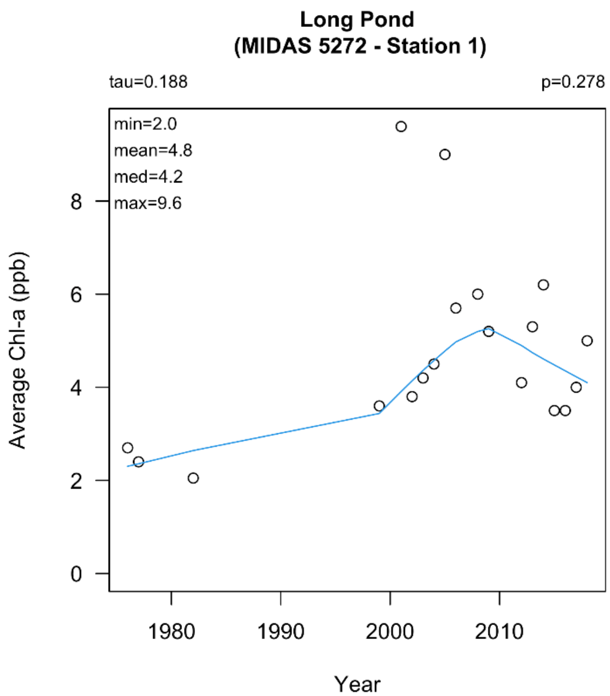
The data range for Chlorophyll-a (Chl-a) is 1976-2020. Samples were taken from epilimnetic cores. For this analysis, all data from a given month and year was averaged together, and all months from that year were averaged to generate the annual average, although as can be seen below, there are very few years with multiple measurements. A Mann-Kendall trend analysis was conducted on the full time series as well as the last 10 years to determine if there were any significant trends in the data.

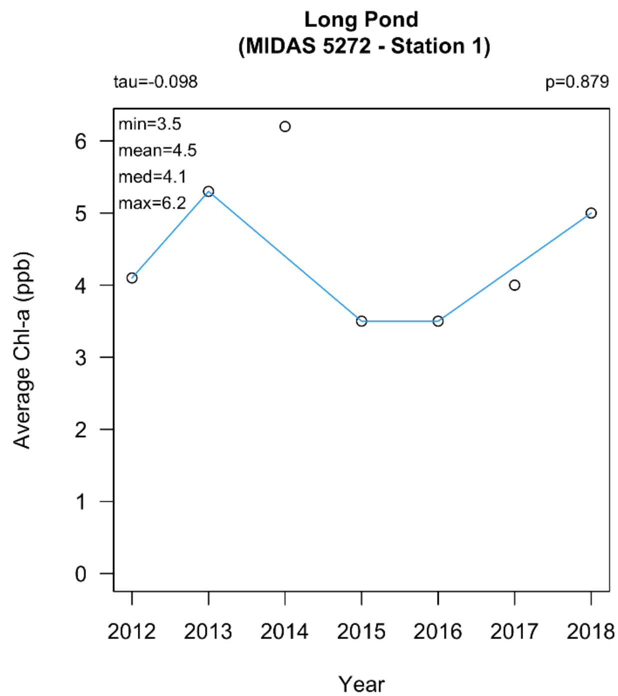
All data from both stations is shown below. For Station 1, the lowest chl-a on record was 2.1 ppb, observed in September 1982. The highest chl-a on record was 9.6 ppb, observed in August 1981. For Station 2, the lowest chl-a was 1.0 ppb observed in May 2009 and the highest chl-a was 10.6 ppb, observed in May 2005.

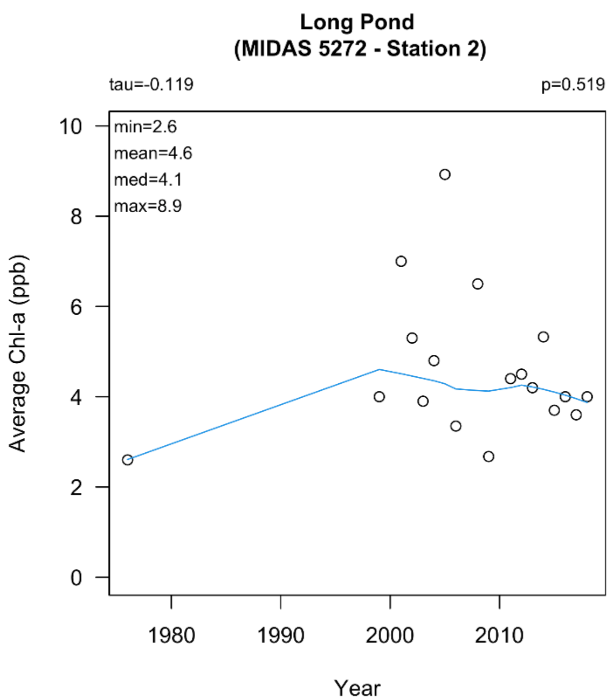


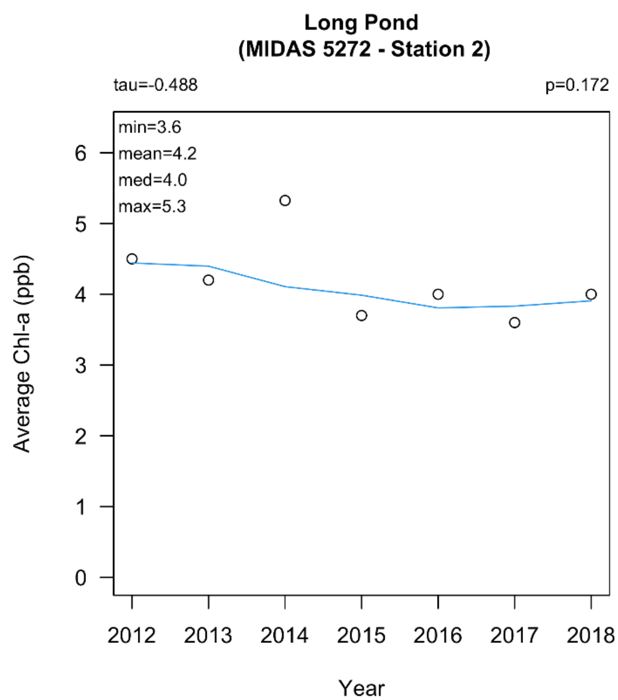


At both stations, **there are no significant short-term or long-term trends in chl-a.** The mean, median, min, and max at the two stations for the whole record were similar in value.

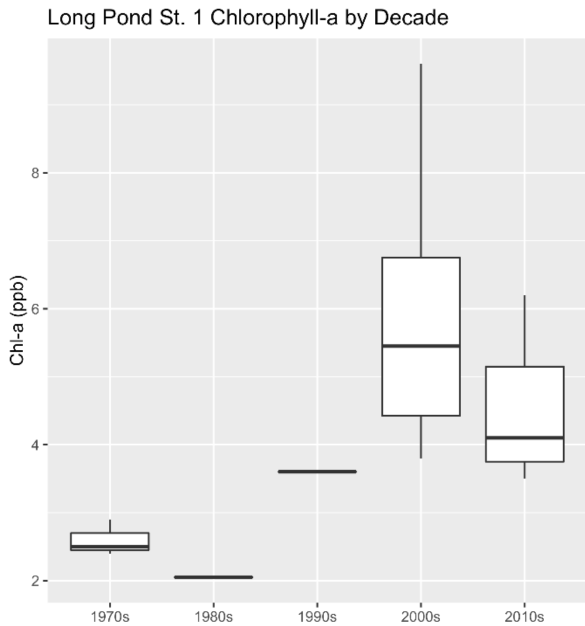

Long Pond
(MIDAS 5272 - Station 1)
tau=0.188
p=0.278
min=2.0
mean=4.8
med=4.2
max=9.6
Average Chl-a (ppb)
Year

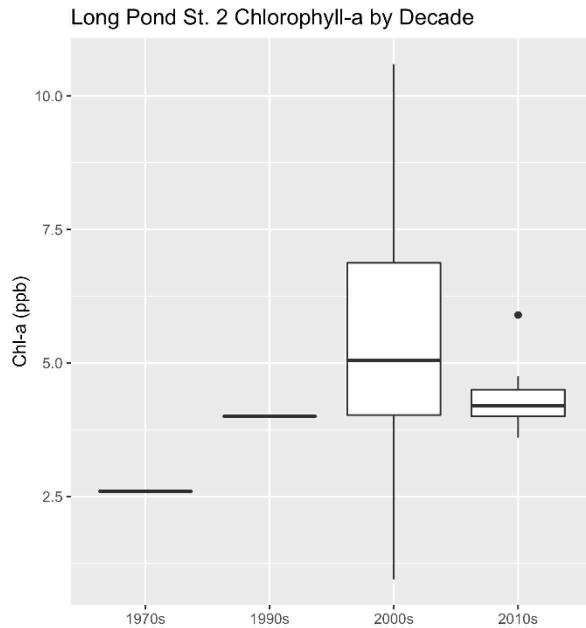

Long Pond
(MIDAS 5272 - Station 1)
tau=-0.098
p=0.879
min=3.5
mean=4.5
med=4.1
max=6.2
Average Chl-a (ppb)
Year


Long Pond
(MIDAS 5272 - Station 2)
tau=-0.119
p=0.519
min=2.6
mean=4.6
med=4.1
max=8.9
Average Chl-a (ppb)
Year


Long Pond
(MIDAS 5272 - Station 2)
tau=-0.488
p=0.172
min=3.6
mean=4.2
med=4.0
max=5.3
Average Chl-a (ppb)
Year

Decadal medians for both stations show the highest chl-a in the 2000s (the worst water clarity) with improvement in the 2010s. The best decade for Station 1 was the 1980s and the best decade for Station 2 was the 1990s, but there was no data from the 1980s for Station 2.



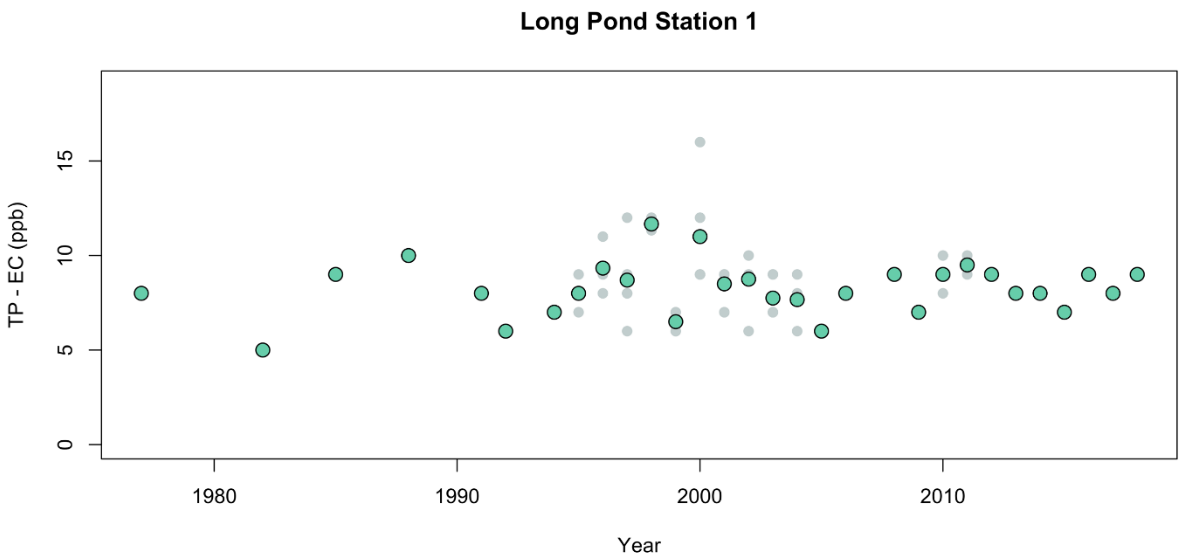


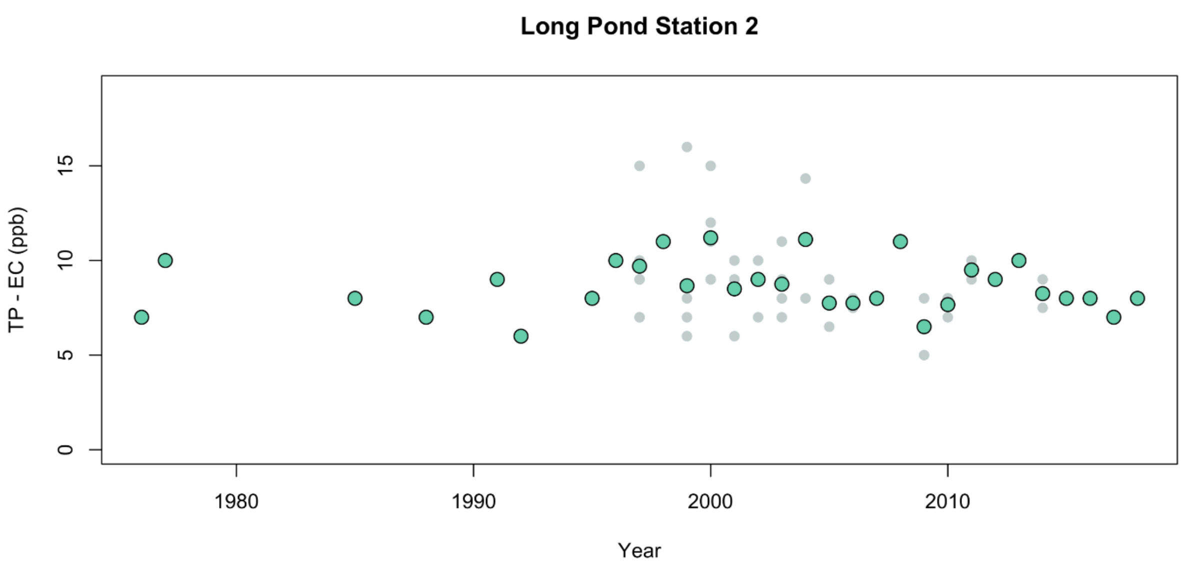
Phosphorus Trends

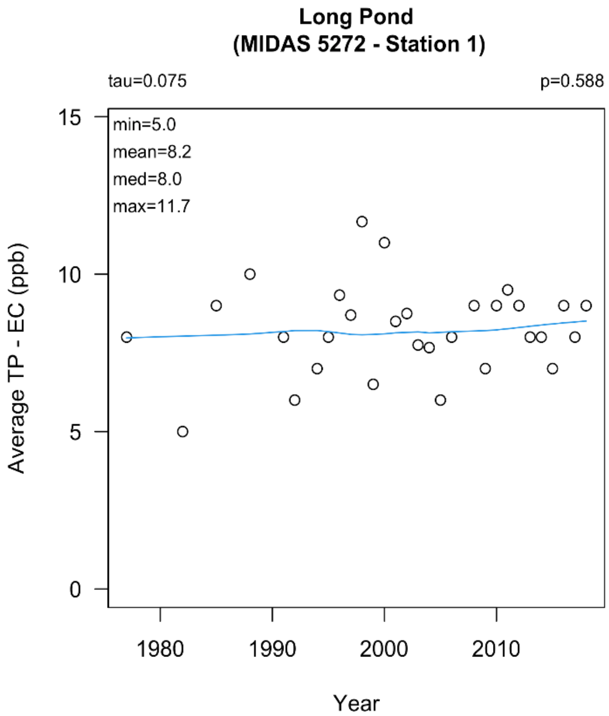
Epicore: The data range for Total Phosphorus (TP) is 1976-2018. Samples were taken from epilimnetic cores. For this analysis, all data from a given month and year was averaged together, and all months from that year were averaged to generate the annual average. A Mann-Kendall trend analysis was conducted on the full time series as well as the last 10 years to determine if there were any significant trends in the data.

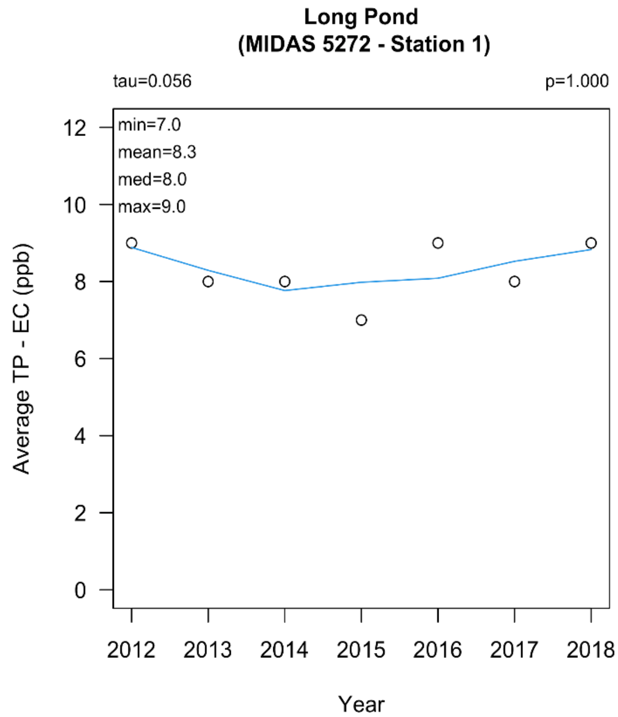
All data from both stations is shown below. For Station 1, the lowest TP on record was 5 ppb, observed in September 1982. The highest TP on record was 16 ppb, observed in June 2000. For Station 2, the lowest TP was 5 ppb observed in May 2009 and the highest TP was 16 ppb, observed in August 1999.

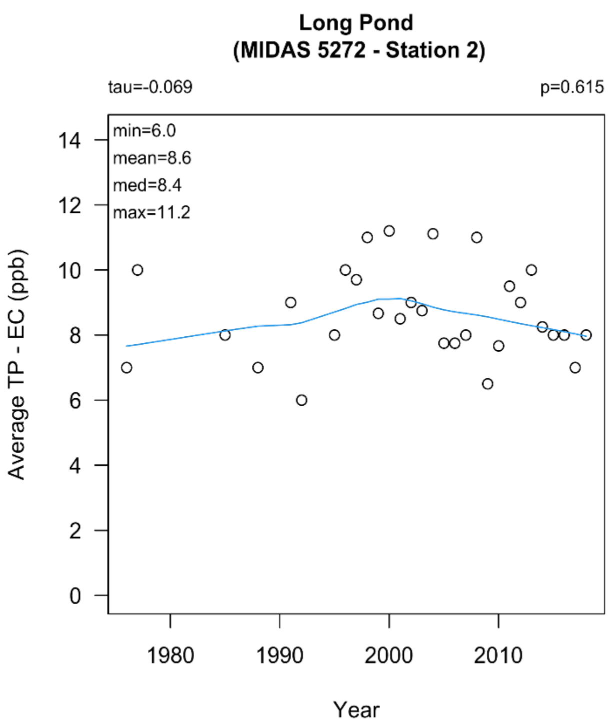
The only trend in TP between both stations is **a strong significant decrease in TP over the past 10 years at Station 2.** The mean, median, min, and max at the two stations for the whole record were similar in value.

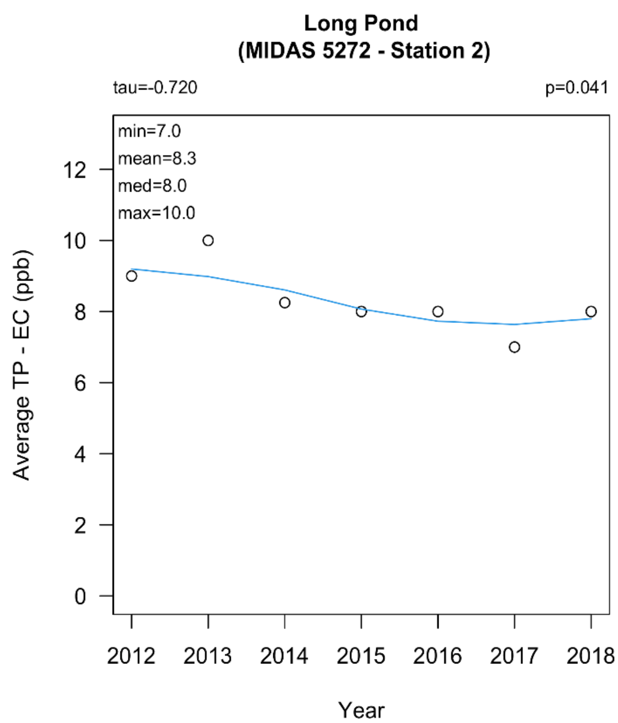

Long Pond Station 1
TP - EC (ppb)
0
5
10
15
1980
1990
2000
2010
Year


Long Pond Station 2
TP - EC (ppb)
0
5
10
15
1980
1990
2000
2010
Year

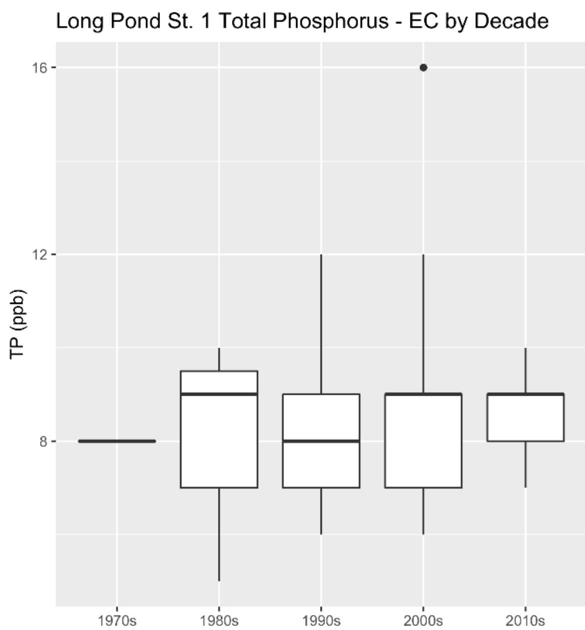

Long Pond
(MIDAS 5272 - Station 1)
tau=0.075
p=0.588
min=5.0
mean=8.2
med=8.0
max=11.7
Average TP - EC (ppb)
Year

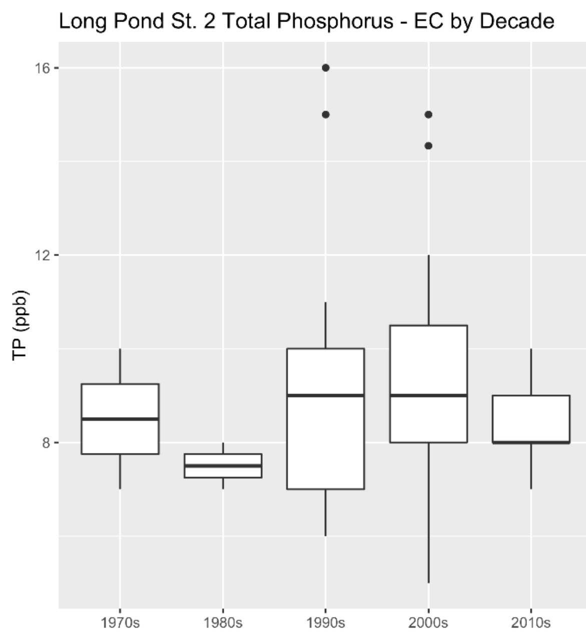

Long Pond
(MIDAS 5272 - Station 1)
tau=0.056
p=1.000
min=7.0
mean=8.3
med=8.0
max=9.0
Average TP - EC (ppb)
Year


Long Pond
(MIDAS 5272 - Station 2)
tau=-0.069
p=0.615
min=6.0
mean=8.6
med=8.4
max=11.2
Average TP - EC (ppb)
Year


Long Pond
(MIDAS 5272 - Station 2)
tau=-0.720
p=0.041
min=7.0
mean=8.3
med=8.0
max=10.0
Average TP - EC (ppb)
Year

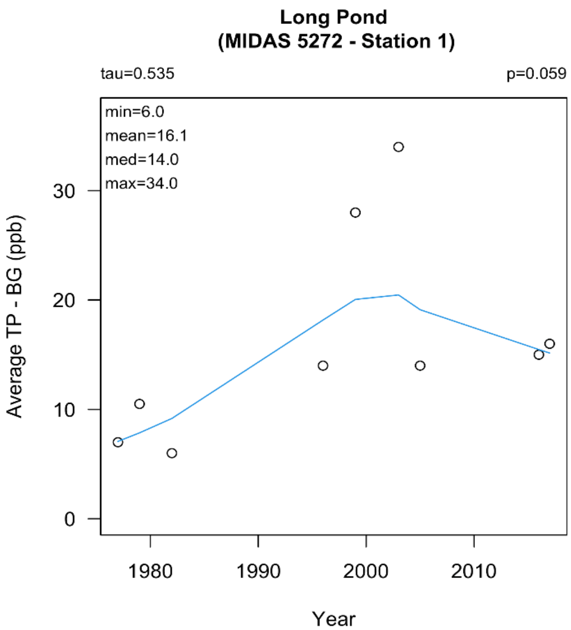
Decadal medians for both stations show no strong trends.

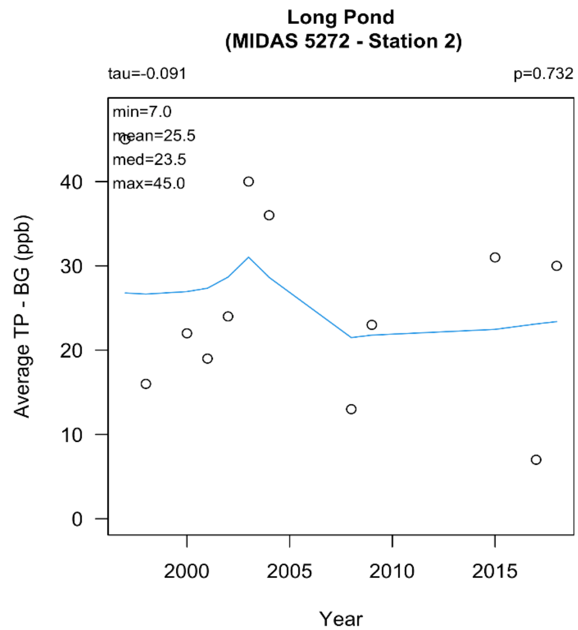




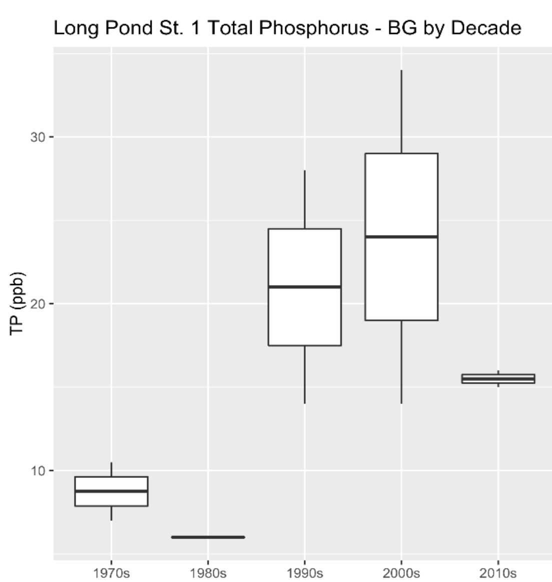
Bottom Grabs: The data range for bottom grabs of TP is 1998-2018. Samples were taken from epilimnetic cores. At both stations, there was only one bottom grab in a given year. A Mann-Kendall trend analysis was conducted on the full time series to determine if there were any significant trends in the data. There was not sufficient data to conduct a short-term trend analysis.

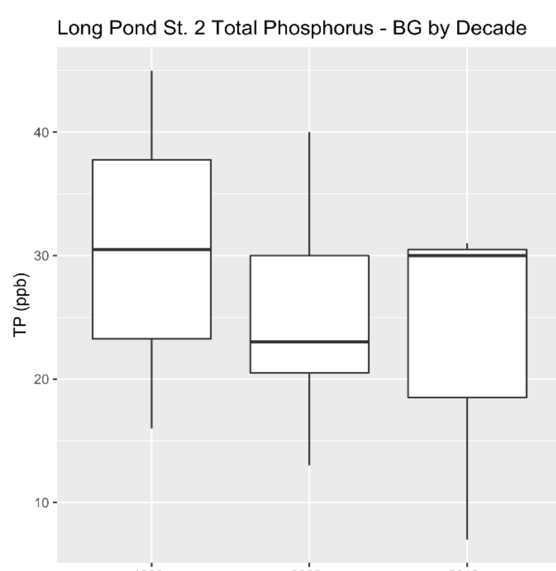
All data from both stations is shown below. For Station 1, the lowest TP on record was 5 ppb, observed in September 1982. The highest TP on record was 16 ppb, observed in June 2000. For Station 2, the lowest TP was 7 ppb observed in August 2017 and the highest TP was 45 ppb, observed in September 1997. The mean, median, min, and max for Station 2 are higher than Station 1. There were no significant trends at either station.





Decadal medians for Station 1 show that the highest bottom phosphorus occurred in the 2000s and the lowest in the 1980s. In contrast, for Station 2 the lowest bottom phosphorus occurred in the 2000s.



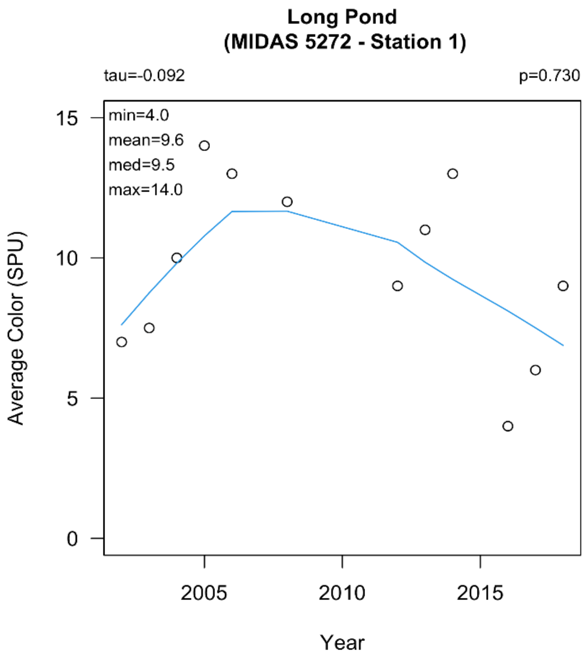


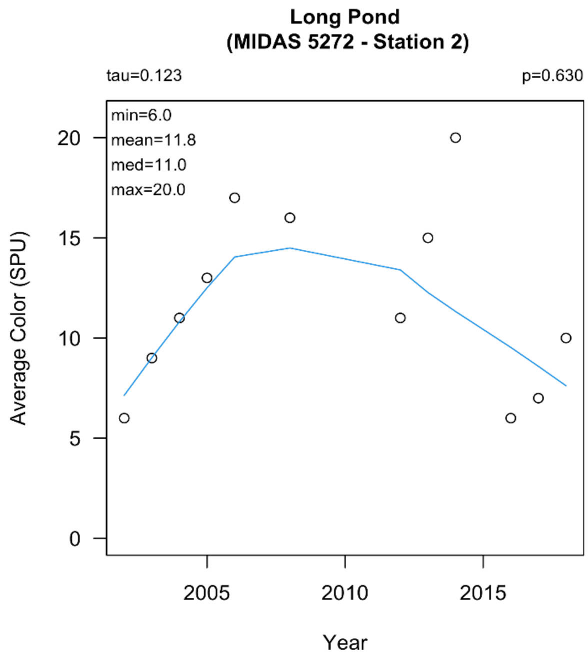
Chemistry Trends

The data range for core samples analyzed for water chemistry (pH, color, conductivity, and alkalinity) was 1979-2018. Only data using consistent methods were used. For pH, pH_Method = G (Granplot) were most frequent. For conductivity, Cond_Method = L (laboratory) was most frequent. There was only one data point per year, so no averaging was done.

pH: At Station 1, there were only 6 data points with a consistent method, so no trend analysis was conducted. pH ranged between 7.04 and 7.24. For Station 2, there were only 6 points as well, ranging from 6.95 to 7.24.

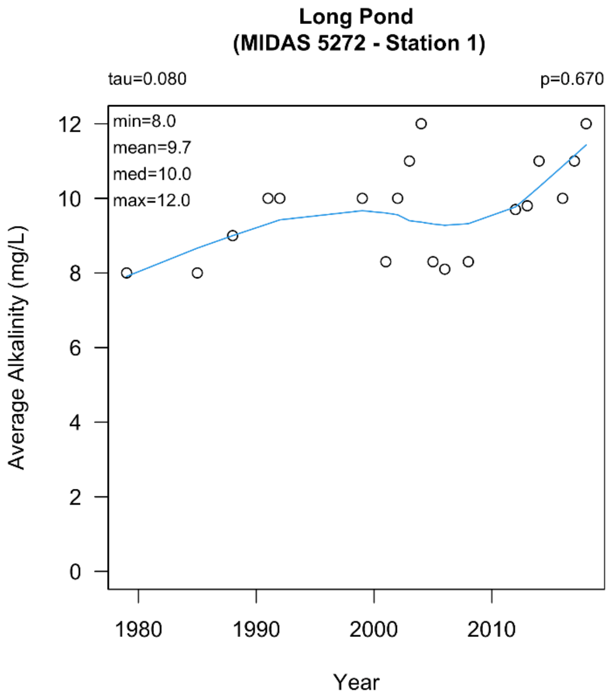
Color: There were no consistent trends in color at either site, although both sites show a peak between 2005 and 2010. The mean, median, min, and max color was higher at Station 2 than Station 1.

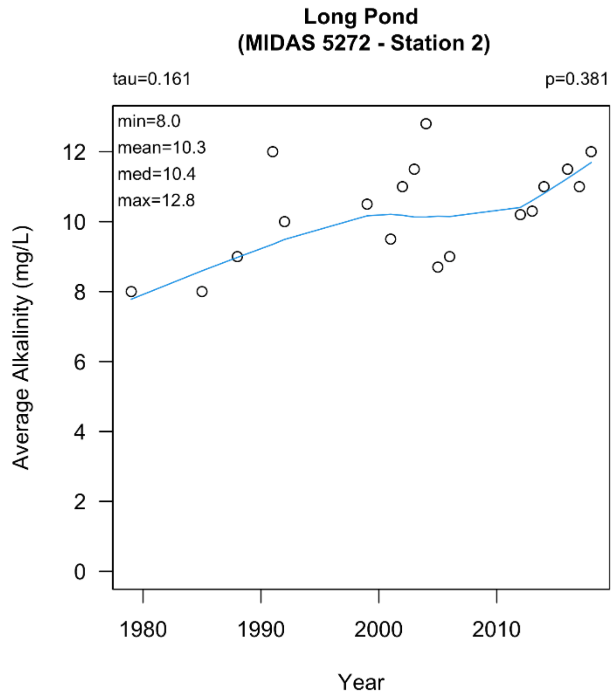


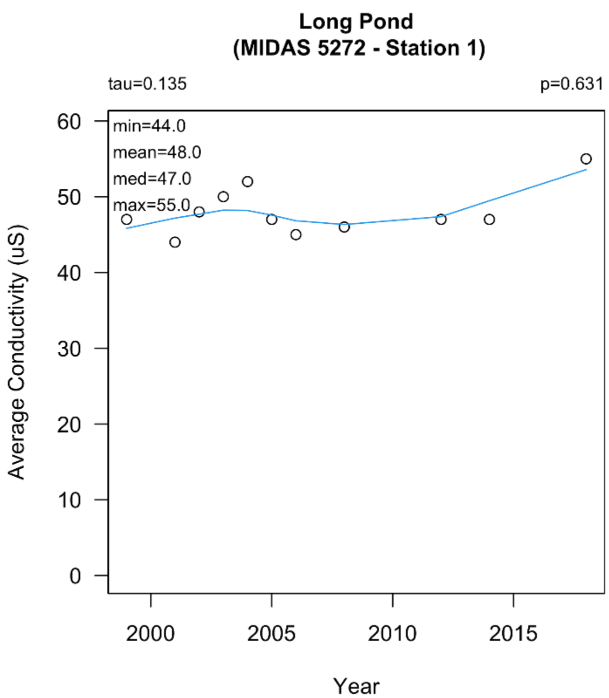


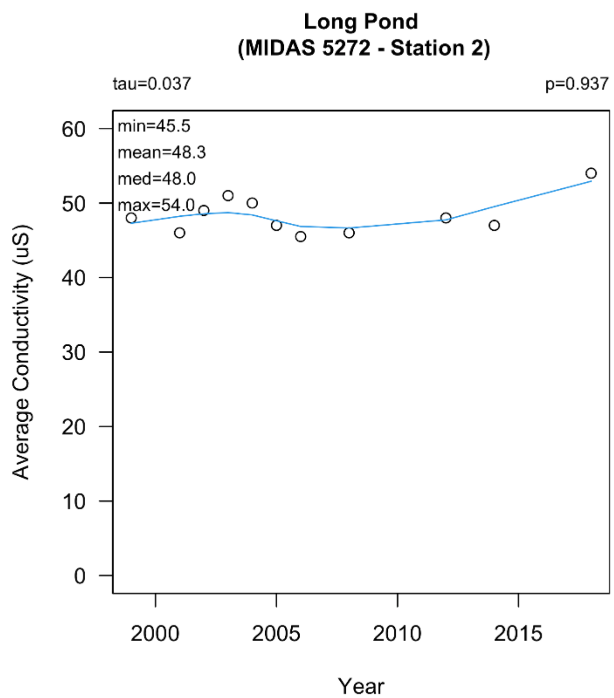
Conductivity: There were no significant trends at either site and mean, median, min, and max values between sites were similar.

Alkalinity: There were no significant trends at either site, and mean, median, min, and max values between sites were similar.



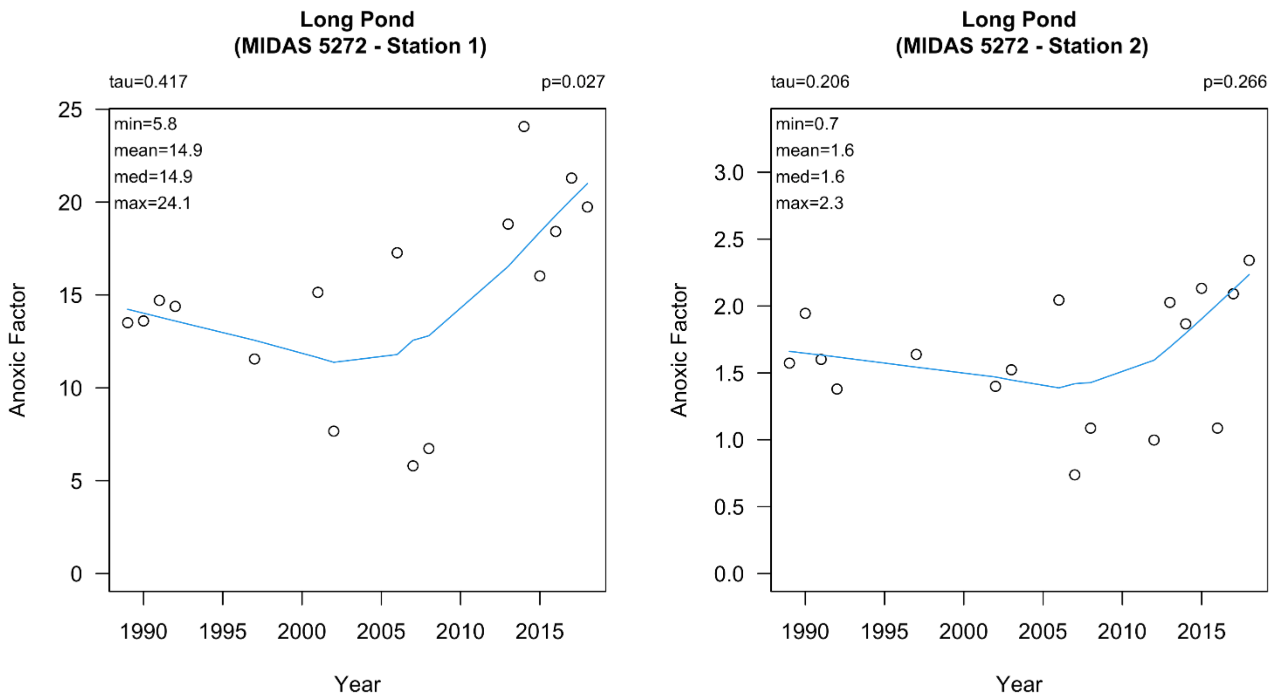






Anoxia Trends

To evaluate trends in anoxia, the anoxic factor was calculated. The anoxic factor is a metric that combines the volume of anoxic water (DO < 2 mg/L) and the lenth of time that the lake is anoxic for. Profile measurements of dissolved oxygen from Lake Stewards of Maine were used to compute the anoxic factor in a given year, as long as there were at least 6 profiles. Larger values of anoxic factor indicate poorer water quality. Enough profiles were available for 17 years between 1989 and 2018. A Mann-Kendall trend analysis was conducted on the full time series to determine if there was any significant trends in the data.

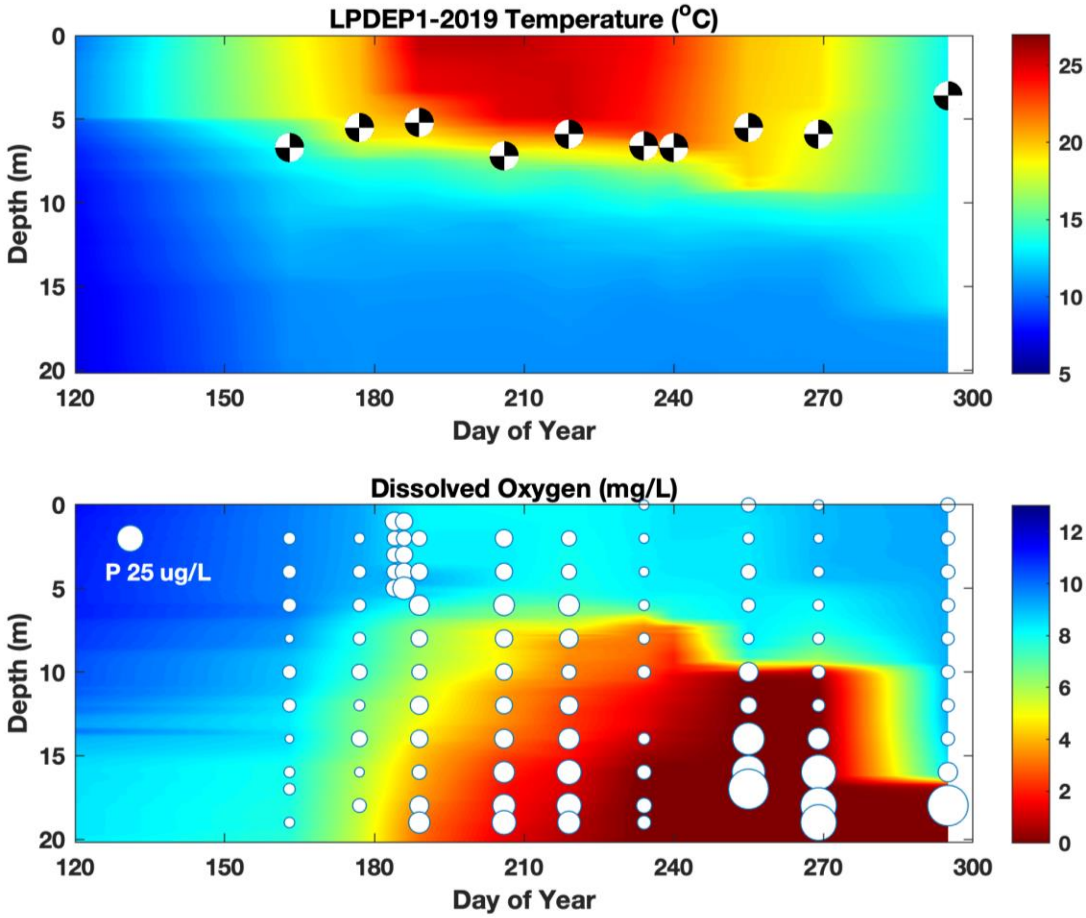


There was a weak significant increase in anoxic factor in the north basin of Long Pond, and no significant change in the south basin. The mean, median, min and max anoxic factor in the north basin were all higher than the south basin. Note that the metalimnetic oxygen minimum in the south basin was not included in these calculations.

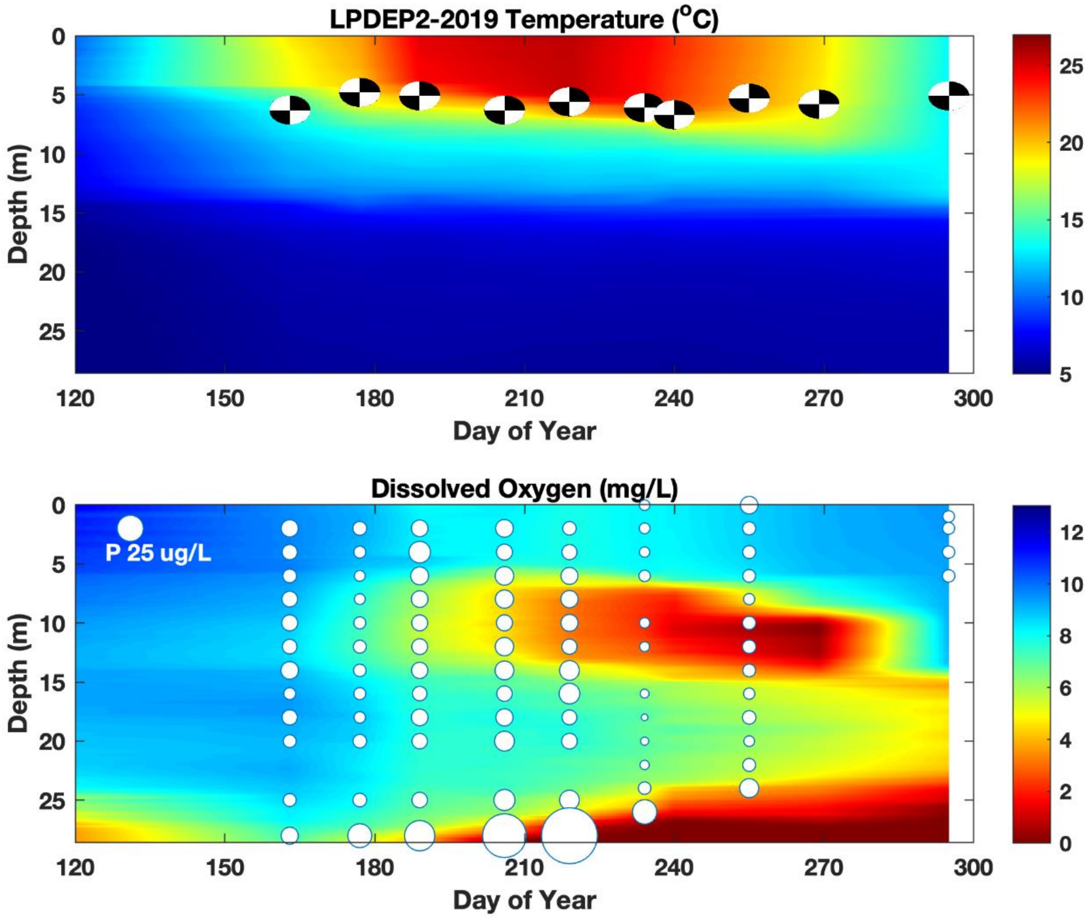
Seasonal Patterns

Water quality profiles are documented in Long Pond by the 7 Lakes Alliance-Colby College Water Quality Initiative. During a typical summer, when Colby interns are available, SDT and profiles of temperature and oxygen are taken every week at the two stations using an In Situ multiparameter water quality sonde. Every two weeks, water samples are collected every 2 m with a Van Dorn sampler for total phosphorus and analyzed at Colby. When interns are not available, SDT and profiles are taken every two weeks and water samples are collected once per month at 4 m intervals.

At Station 1, stratification onset occurs in June and the lake begins to turn over in October. Anoxia onset occurs in July and lasts until the lake is fully mixed, which usually occurs in November. The amount of phosphorus in the bottom waters continues to increase during this period, eventually being mixed up to surface; this is often when the worst water clarity is observed.



At Station 2, onset of stratification also begins in June and turnover begins in October. Anoxic conditions also start in July, but anoxic waters occupy a much smaller portion of the water column than at Station 1 (which is why the anoxic factor is higher at 1 than 2). High phosphorus concentrations are observed in this anoxic region. The southbasin also has a low point of oxygen in the middle of the water column, called a metalimnetic oxygen minimum (MOM). More work needs to be done to understand the formation, extent, and impact of the MOM, but there does not appear to be an increase of phosphorus in this layer as there is in the bottom.



LPDEP2-2019 Temperature (°C)
Depth (m)
Day of Year
Dissolved Oxygen (mg/L)
P 25 ug/L
Depth (m)
Day of Year

APPENDIX D. Phosphorus Reduction Estimates Methods

Load reduction estimates for the 2022 Long Pond WBMP were developed based on three methods including: **1)** the US EPA Region 5 model to estimate P reductions that can be achieved by addressing NPS sites from the 2020 watershed survey (14 kg/yr)[34], **2)** Maine DEP Relational method to estimate load reductions from other areas and land cover types in the watershed (21 kg north basin, 39 kg south basin), and **3)** use of the empirical watershed model prepared by WRS (86 north basin, 98 south basin). The use of the three different models assisted with the developing the best estimates for load reductions to Long Pond. Each step in calculating load reductions was used for the final load reduction estimates to help set the in-lake water quality target for Long Pond over the next 10 years. A brief summary of each method is provided below.

1) <u>Region 5 Model</u>

The US EPA Region 5 (R5) Model[35] is an Excel spreadsheet-based model that provides estimates of sediment and nutrient load reductions from the implementation of Best Management Practices (BMPs). This method is used extensively for developing Pollutants Controlled Reports (PCR) for US EPA 319 grant projects. This method has been used to calculate load reduction estimates for several recent WBMP projects including the Georges Pond WBMP, Great Pond WBMP, and China Lake WBMP.

R5 is used in this application using a desktop assessment of available watershed survey data (site description, land use type, problems/solutions, area of exposed soil, and photos of the sites). Rather than calculating soil loss estimates for 148 individual sites identified during the 2020 watershed survey, a subset of representative sites were selected based on the total number of sites (or percentage of sites) by land use type within each of the three impact categories (high, medium, or low). This included calculations for 100% of all high impact sites (16 sites), ~50% of medium impact sites (15 sites), and 10% of low impact sites (7 sites).

Based on previous recommendations from Jeff Dennis (Maine DEP), a soil P concentration of 0.00012 lb P/lb soil was used in the model. A second set of estimates were run at the higher R5 default concentration (0.0005 lb P/lb soil) which yielded a value twice the value of the lower P concentration. The lower value was used for the Long Pond reduction estimates. R5 defaults were used for the sediment and nitrogen values. The R5 Gully Stabilization and Bank Stabilization was used for all sites. Lateral Recession Rates (LRR) were entered into the model based on the site description and photographs for each site. BMP efficiency was set at 0.75 for all sites for simplicity. A spreadsheet was prepared that includes variables used for each site and sorted by impact. The average of each parameter (sediment, P, N) was multiplied by the total

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[34] Based on a soil P concentration of 0.00012 lbs P/lb soil.
[35] https://www.epa.gov/nps/region-5-model-estimating-pollutant-load-reductions

number of sites by impact and then summed to come up with the final pollutant reduction estimates (**65 tons/yr sediment, 14 kg/yr P, and 52 kg/yr N**). for the NPS sites (Table E1).

Table E1. *Region 5 soil loss estimates for 2020 Long Pond NPS sites.*

Total: High Impact Sites (16 sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
12.58	2.55	21.35
Total: Medium Impact Sites (61 sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
39.85	17.45	73.08
Total: Low Impact Sites (71 Sites)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
12.68	9.94	20.39

Total (P= lbs/yr)		
Sediment (t/yr.)	P (lbs./yr.)	N (lbs./yr.)
65	30	115
Total (P= kg/yr)		
Sediment (t/yr.)	P (kg/yr.)	N (kg/yr.)
65	**14**	**52**

Soil P Concentration (lb/lb soil) = 0.00012

2) <u>DEP Relational Method</u>

The *Relational Method for Estimating Required and Projected Load Reductions*[36] is the second method used to estimate potential load reductions that could be achieved in the Long Pond watershed. This model estimates the percent of various sources of phosphorus in the watershed by land use type expressed as a fraction of the total contributing P sources x the fraction to be addressed x a BMP efficiency. The result is an estimate of the fraction of the load reduced for each land use type.

To get there, a land cover analysis was completed to calculate the area of each land cover type within the Long Pond watershed using the NLCD (2019) land cover layer modified by Ecological Instincts in GIS to include the E921 Roads layer and adjusting the grassland/herbaceous layer for areas that were clearly recent timber harvests. Land cover was clipped to the watershed boundary and then refined by basin (north basin, south basin and indirect drainage basins). A P export coefficient was assigned to each land cover type to estimate the P load from each land cover type to come up with a value to use for the fraction of the load for each category for each basin (Table E2).

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[36] Jeff Dennis, Division of Watershed Management, MEDEP, n.d.

Table E2. *P export coefficients, land areas, and fraction of P load for land cover types in the Long Pond watershed.*

LC Type	P Export Coefficient (kg/ha/yr)	Total ha (LPN)	P Load (kg/yr)	Fraction of Load (LPN)	Total (LPS)	P Load (kg/yr)	Fraction of Load (LPS)
Pasture/Hay	0.3	28	8	0.016	362	109	0.144
Cultivated Crops	1.0	19	19	0.037	-	-	0.000
Developed, Low Intensity	0.5	39	19	0.038	47	23	0.031
Developed, Medium Intensity	0.7	11	7	0.015	11	7	0.010
Developed, High Intensity	0.7	1	1	0.001	1	1	0.001
Developed Open Space	0.7	147	103	0.200	194	136	0.179
Roads	0.6	89	53	0.104	120	72	0.095
Deciduous Forest	0.08	1640	131	0.255	1,102	88	0.116
Evergreen Forest	0.08	306	24	0.047	599	48	0.063
Mixed Forest	0.08	1260	101	0.195	2,151	172	0.227
Open Water	0.1	76	8	0.015	64	6	0.008
Scrub/Shrub	0.08	60	5	0.009	74	6	0.008
Barren Land (Rock/Sand/Clay)	0.25	2	0	0.001	3	1	0.001
Woody Wetlands	0.1	209	21	0.041	621	62	0.082
Emergent Herbaceous Wetlands	0.15	19	3	0.005	57	9	0.011
Grassland/Herbaceous	0.1	24	2	0.005	51	5	0.007
Recent Timber Harvesting	0.25	34	8	0.016	49	12	0.016
TOTAL		**3963**	**516**	**1.00**	**5504**	**757**	**1.00**

Table E3. *DEP Relational Method for estimating phosphorus reductions in the Long Pond watershed.*

LONG POND (NORTH BASIN)

Source Type	Sub-type	Fraction of total load	Fraction Addressed	Expected BMP Efficiency	Load Fraction Reduced	Total P Reduced (kg/yr)
Agriculture						
	Row Crop	0.037	0.2	0.37	0.3%	1.4
	Hayland/Grassland	0.016	0.2	0.5	0.2%	0.8
						2.2
Urban Development						
	Low Intensity Development	0.038	0.2	0.42	0.3%	1.6
	Medium Intensity Development/Com	0.015	0.2	0.40	0.1%	0.6
	High Intensity Development	0.001	0.15	0.40	0.0%	0.0
	Developed Open Space	0.200	0.15	0.40	1.2%	6.2
	Roads	0.104	0.3	0.40	1.2%	6.4
						14.9
Non-Developed Land						
	Unmanaged Forest	0.497	0	0	0.0%	
	Open Water	0.015	0	0	0.0%	
	Scrub/Shrub	0.009	0	0	0.0%	
	Emergent Wetlands	0.010	0	0	0.0%	
	Forested Wetlands	0.041	0	0	0.0%	
	Timber Harvesting	0.016	0.1	0.78	0.1%	0.6
Atmospheric			0	0	0.0%	
Waterfowl			0	0	0.0%	
Septics			0	0.75	0.0%	
	Total	1.00			3.5%	17.8

Load Reduction (north basin)

TP Export Load kg TP (current)	516
TP Export Loading Target	497
TP Reduction Needed	18
% Reduction Possible	3.5%

LONG POND (SOUTH BASIN)

Source Type	Sub-type	Fraction of total load	Fraction Addressed	Expected BMP Efficiency	Load Fraction Reduced	Total P Reduced (kg/yr)
Agriculture						
	Row Crop	0.000	0.2	0.37	0.0%	
	Hayland/Grassland/Hobby Farm	0.151	0.2	0.5	1.5%	11.4
Urban Development						
	Low Intensity Development	0.031	0.2	0.42	0.3%	2.0
	Medium Intensity Development/Com	0.010	0.2	0.4	0.1%	0.6
	High Intensity Development	0.001	0.15	0.4	0.0%	0.0
	Developed Open Space	0.180	0.15	0.4	1.1%	8.2
	Roads	0.095	0.3	0.4	1.1%	8.6
						19.4
Non-Developed Land						
	Unmanaged Forest	0.407	0	0	0.0%	
	Open Water	0.008	0	0	0.0%	
	Scrub/Shrub	0.008	0	0	0.0%	
	Emergent Wetlands	0.011	0	0	0.0%	
	Forested Wetlands	0.082	0	0	0.0%	
	Timber Harvesting	0.016	0.1	0.78	0.1%	0.9
Atmospheric			0	0	0.0%	
Waterfowl			0	0	0.0%	
Septics			0	0.75	0.0%	
	Total	1.00			4.2%	31.8

Load Reduction (south basin)

TP Export Load kg TP (current)	757
TP Export Loading Target	725
TP Reduction Needed	32
% Reduction Possible	4.2%

The Relational Method estimates reductions of 19 kg/yr from shoreline and non-shoreline development (8.5 kg/yr north basin, 10.8 kg/yr south basin), 15 kg/yr from roads including paved and gravel roads throughout the watershed (6.4 kg/yr north basin, 8.6 kg/yr south basin), 14 kg/yr from agricultural land (2.2 kg/yr north basin, 11.4 kg/yr south basin), and <2 kg/yr from timber harvesting (0.6 kg/yr north basin, 0.9 kg/yr south basin).

3) Empirical Model Application

Using the load reductions estimated above, WRS estimated total load reductions that could be achieved by reducing phosphorus from watershed management activities in both the Long Pond and upstream Great Pond watershed (Appendix E). The load reductions from the DEP Relational Method were separated by subdrainage[37] by Ecological Instincts for use by WRS in the model as follows:

a. **North Basin (18 kg/yr)-** 16 kg/yr north basin direct, 2 kg/yr Whittier Pond, 0 kg/yr Kidder Pond.

b. **South Basin (32 kg/yr)**- 22 kg/yr south basin direct, 10 kg/yr Ingham Pond.

Using the load reductions estimated above, WRS estimated total load reductions that could be achieved by reducing P through practical application of BMPs in the watershed in both the Long Pond and Great Pond watershed. Because of the large influence of Great Pond on the P load in the north basin, and the downstream influence of the north basin on the south basin, additional reductions above what was applied in the direct watershed of the south basin can be achieved by reducing the P load in the Great Pond watershed.

Additional non-direct load reductions from the empirical model:

c. **North Basin (68 kg/yr)-** An additional 54 kg/yr from reducing the watershed load in the Great Pond watershed, and 14 kg P/yr reduction from groundwater/septic systems;

d. **South Basin (66 kg/yr)**- 60 kg/yr reduction from north basin reductions (direct & indirect load reductions) and a 6 kg/yr reduction from groundwater/septic systems.

The total estimated P load reductions for Long Pond from the empirical model total 124 kg/yr including 38 kg/yr to the direct watersheds of the north and south basins, 66 kg/yr from indirect watersheds, and 20 kg/yr from septic systems.[38]

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[37] Based on the % of sites by basin from the 2020 watershed survey.

[38] An additional 60 kg P/yr reduction in the indirect load to the south basin from the north basin is not included in this total. The P reduction from the north basin to the south basin is the result of P reductions from watershed management in the watersheds of upstream Great Pond and the direct watershed of the north basin.

APPENDIX E. REVIEW OF LONG POND PHOSPHORUS LOADING

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413-219-8071

February 27, 2022
To: Long Pond TAC
From: Ken Wagner, WRS Inc.

Review of Long Pond Phosphorus Loading

Prior Loading Assessment

From data provided to WRS, more recent loading to Long Pond has been evaluated. Work done by DEP and consultants prior to 2010 had established estimated loads. Additional data through 2013 were applied by WRS in 2016 to revisit those loads, with the following table provided as a summary.

Table 1. Phosphorus loading summary from WRS 2016.

Source	Water	P Load				
	(MM3/yr)	(kg/yr)				
	[Average]	[Low]	[High]	[Best Est]	TMDL	Notes
North Basin						
Direct Precipitation	5.8	50	250	120	87	Lower P concentration applied in TMDL
Direct Groundwater	1.9	100	185	125	209	Lower attenuation applied in TMDL
Surface Flow						
Direct Drainage	12.6	252	290	271	617	No attenuation applied in TMDL
Great Indirect Drainage	96.5	673	1121	897	1123	Treated as point source in TMDL with limited data, but fair agreement among assessments
Whittier Indirect Drainage	6.6	76	132	104		
Kidder Indirect Drainage	1.3	15	26	21		
Discharges	0.0	0	0	0	0	None known for Long Pond
Waterfowl	0	25	100	50	0	Not addressed in TMDL
Internal Release	0	13	306	140	108	Close agreement between assessments
Total North Basin	124.6	1204	2410	1728	2144	TMDL value within range of WRS estimates
South Basin						
Direct Precipitation	5.75	50	250	120	86	Lower P concentration applied in TMDL
Direct Groundwater	1.85	100	185	125	54	Higher attenuation applied in TMDL
Surface Flow						
Direct Drainage	17.4	348	402	375	559	No attenuation applied in TMDL
From North Basin	121.6	758	1263	1010	2008	Treated as point source in TMDL, different flushing rates account for much of discrepancy
Ingham Indirect Drainage	10.3	119	206	163		
Discharges	0	0	0	0	0	None known for Long Pond
Waterfowl	0	25	100	50	0	Not addressed in TMDL
Internal Release	0	13	100	60	65	Close agreement between assessments
Total South Basin	156.9	1413	2506	1903	2772	TMDL load likely overestimated due to N basin losses

The fundamental conclusion was that P concentrations in Long Pond were largely a function of watershed loading, with the North Basin most impacted by inputs from Great Pond and the South Basin most impacted by flow from the North Basin. The range of annual loads appeared potentially large, but there were limited data available for narrowing down the range of actual watershed inputs. Internal loading was not viewed as a dominant influence.

Current Loading Analysis
In this new analysis, data collected by DEP from 2013 through 2018 or 2019 and data provided by Colby College for 2015-2021 are used to examine P loading to Long Pond. Examination of the DEP database suggests that there has not been an appreciable change in total phosphorus, chlorophyll-a, or Secchi transparency in recent years. The means of values for the period of 1976-2013 are not significantly different than those for the 2014-2019 period (Tables 2-4).

Table 2. Summary of total phosphorus data collected by ME DEP for Long Pond

Station	Basin	Depth (m)	Date range	TP (ug/L)	n
1	N	<10 m	1976-2013	8.5	85
1	N	<10 m	2014-19	8.7	7
1	N	10-15 m	1976-2013	14.1	19
1	N	10-15 m	2014-19	11.0	1
1	N	>15 m	1976-2013	24.1	39
1	N	>15 m	2014-19	15.5	4
2	S	<10 m	1976-2013	8.5	105
2	S	<10 m	2014-2019	7.9	7
2	S	10-15 m	1976-2013	8.4	8
2	S	10-15 m	2014-2019		0
2	S	>15 m	1976-2013	21.5	40
2	S	>15 m	2014-2019	22.7	3

Table 3. Summary of chlorophyll-a data collected by ME DEP for Long Pond

Station	Basin	Date range	Chl-a (ug/L)	n
1	N	1976-2013	4.6	16
1	N	2014-2018	4.4	5
2	S	1976-2013	4.3	31
2	S	2014-2018	4.4	7

Table 4. Summary of Secchi transparency data collected by ME DEP for Long Pond

Station	Basin	Date range	SDT (m)	n
1	N	1976-2013	6.4	418
1	N	2014-2018	6.4	79
2	S	1976-2013	6.1	377
2	S	2014-2018	6.3	89

An effort to examine the Anoxic Factor (AF), a measure of the area and duration of exposure to low oxygen (set at 2 mg/L) was hampered by changes in the area and volume of each basin derived from newer bathymetric data and mapping. The AF remains low in the South Basin (<10 even if the metalimnetic oxygen minimum is counted) but AF increased dramatically in the North Basin with use of newer bathymetry data. Comparison of AF values for the North Basin 2015 using old and new bathymetry yielded respective values of 5.7 vs. 16.4. Considerable recalculation work will be needed to generate a valid comparison, but as AF values >10 represent a concern, the effort is justified.

What remains clear is that oxygen is depleted in the North Basin at depths greater than 9 to 10 m by the end of summer, exposing up to a third of the bottom of that basin to low oxygen and possible P release. In the South Basin the oxygen regime is more complicated, with oxygen depletion in the deepest part of the basin (>23-25 m) and also in the metalimnion (mostly 8-12 m). There is an oxic zone in between the oxygen minima that will limit any impact from deep anoxia, but the effect of the metalimnetic oxygen minimum on P release is uncertain.

The cause of the metalimnetic oxygen minimum is of interest. There are two competing theories, not mutually exclusive, but the relative importance of each is unknown. The first is that organic particles, including dying algae, settle to the thermocline region and decay, depleting the oxygen in that zone. The alternative is that the oxygen demand from sediment in the depth zone where the metalimnetic minimum is observed is high enough to deplete oxygen above it and the impact extends laterally into areas of the same depth over deeper water. Oxygen migrates laterally within a temperature isopleth much easier than it moves vertically across a temperature gradient, so this is a possible mechanism of oxygen loss laterally away from the oxygen-demanding sediment. If settling organic particles are responsible, there may not be any major internal loading involved, but if the oxygen demand from sediment in the 8-12 m zone is the cause of low oxygen, there may be P release from that sediment that needs to be accounted for in the internal loading analysis.

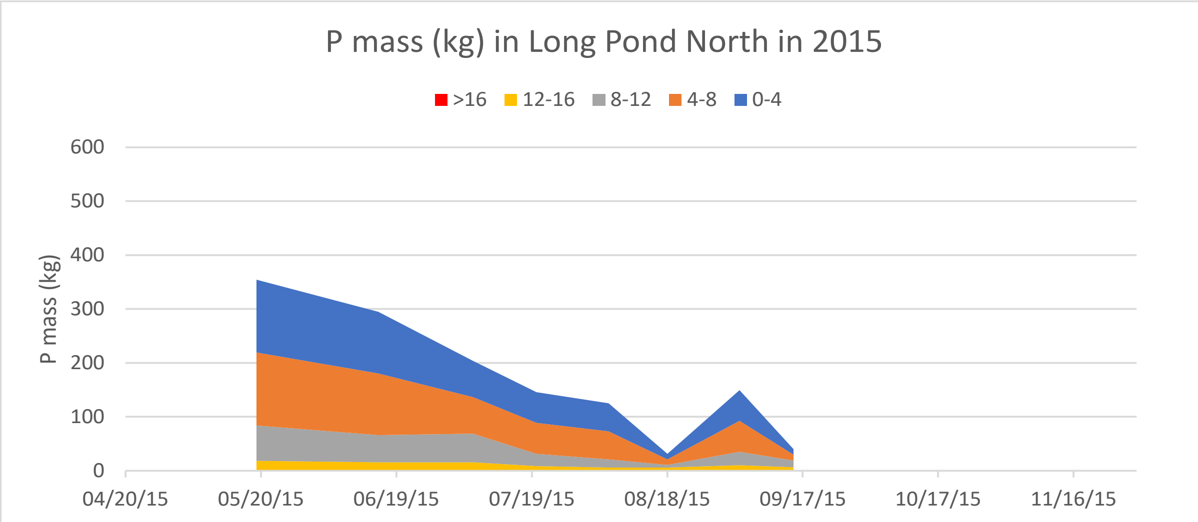
The current area, volume, and mean depth of the North and South Basins (Table 5) suggest slightly larger area and volume for the North Basin but slightly deeper mean depth for the South Basin. The maximum depth of the South Basin is considerably deeper than that of the North Basin, but the volume associated with that extra depth is relatively small. The current bathymetry represents a loss of area and volume from Long Pond in comparison to values applied in the previous analyses (i.e., 2009 and 2016).

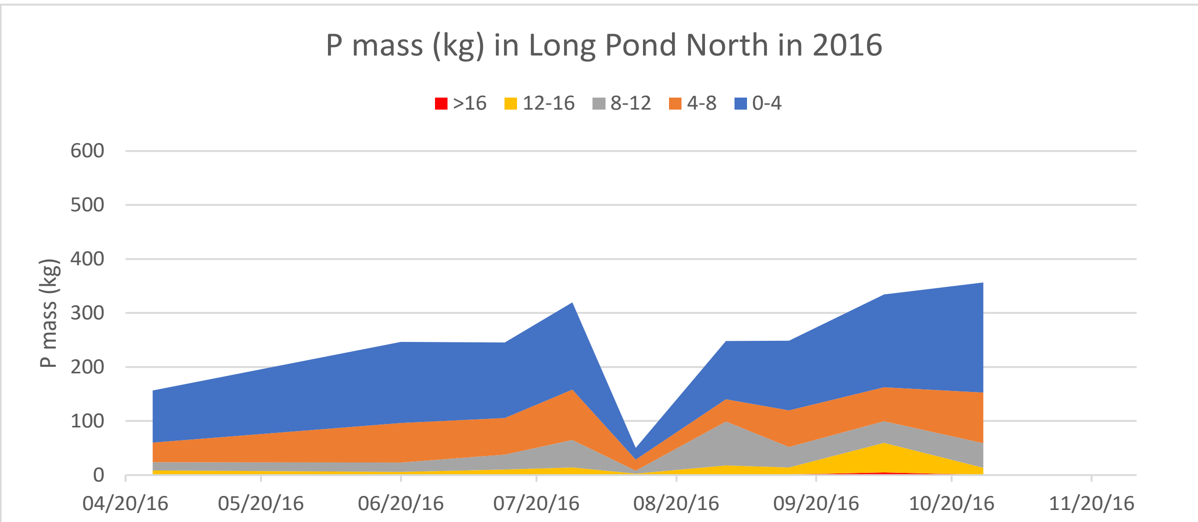
Table 5. Area, volume and mean depth of Long Pond basins

	North	South
Basin Area (million m2)	5.1	4.1
Basin Volume (million m3)	38.3	31.0
Mean Depth (m)	7.5	7.6

Calculation of the mass of phosphorus in each defined water layer in each basin (Figures 1 and 2) provides an overview of the pattern of P mass in each basin over the growing season in each of seven years (2015-2021). Mass is determined as the average concentration of P at depths included in the defined layer times the volume of that layer based on the most recent bathymetry. Typically, only one or two concentration values are available for any given layer, so there is error in the extrapolation, but the pattern over time can provide insights. The graphs are displayed with a common range of dates for easy comparison, but the start and end dates for monitoring in any given year do vary. All years provide some data for May through September, with some years having data as early as March and some as late as November.

Figure 1. Mass of phosphorus in defined depth strata of the North Basin of Long Pond





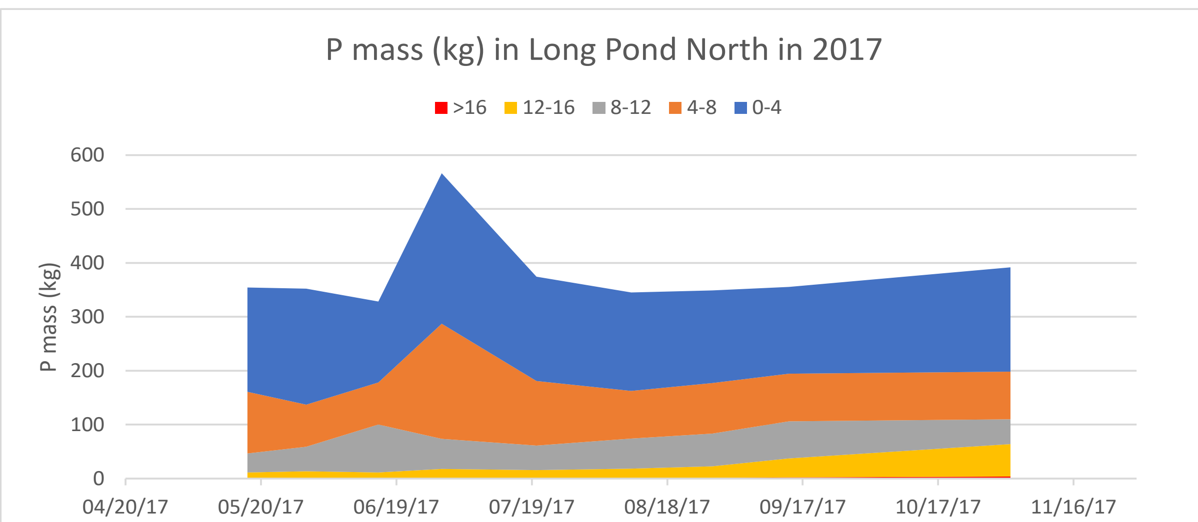
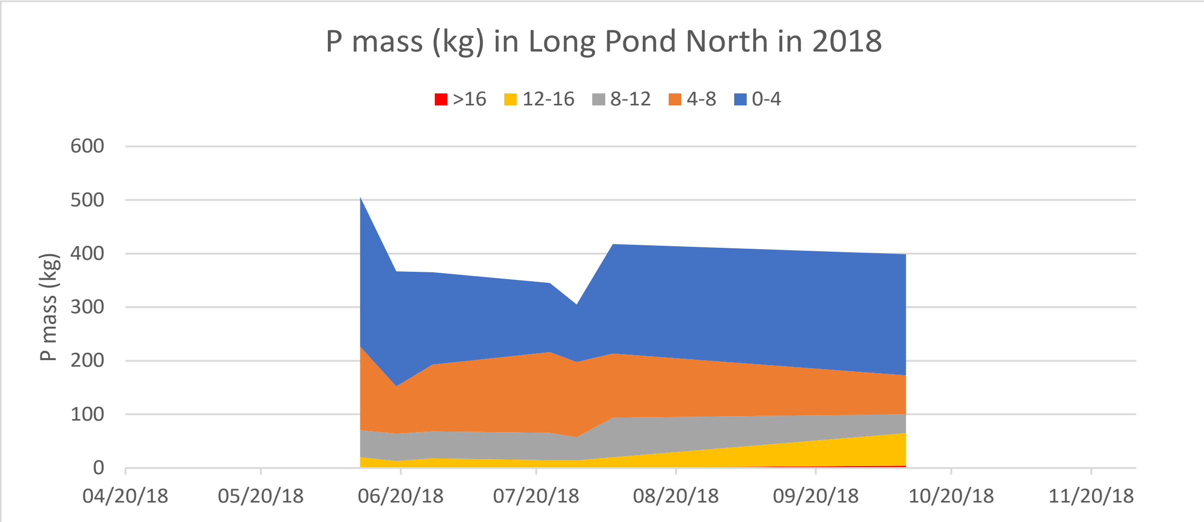
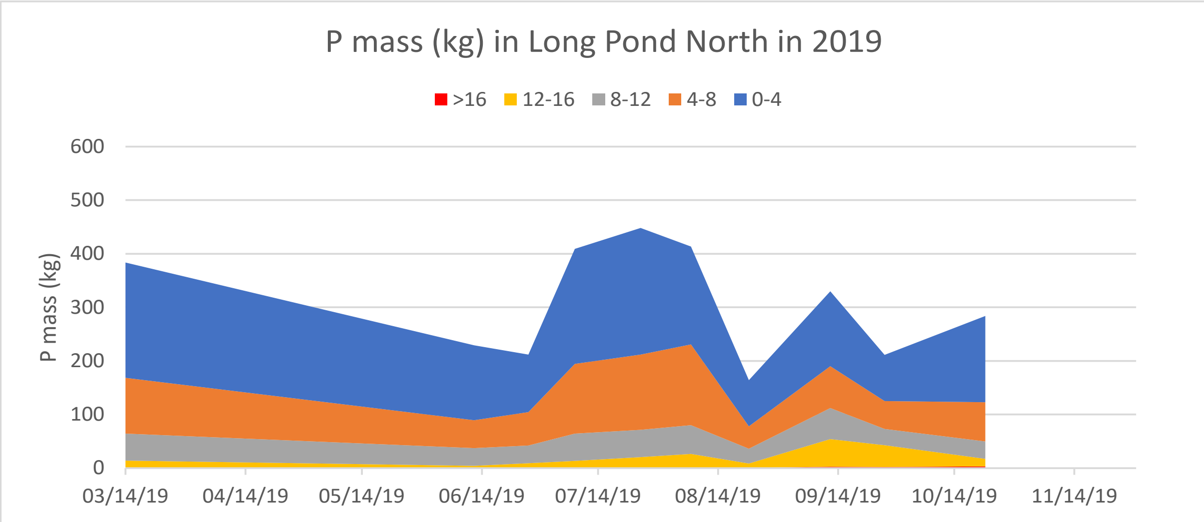


Figure 1. continued





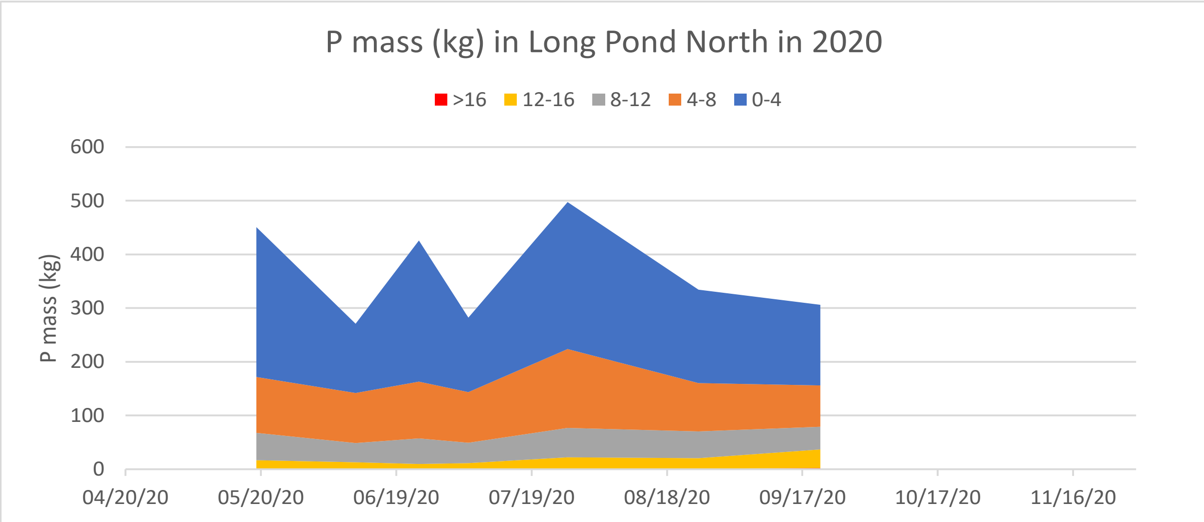


Figure 1. continued

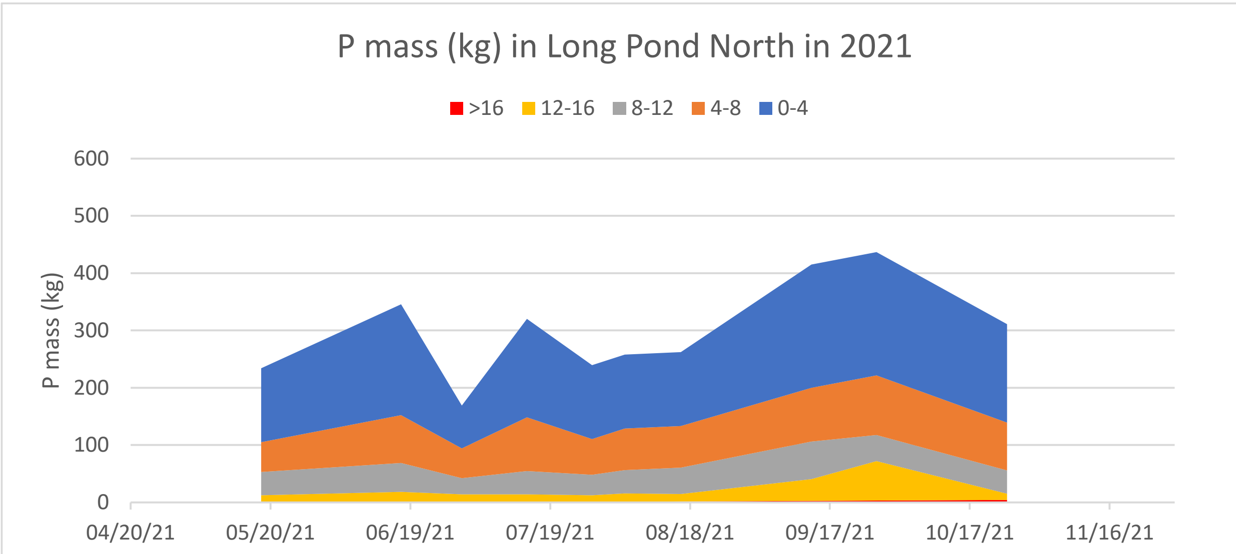


Figure 2. Mass of phosphorus in defined depth strata of the South Basin of Long Pond

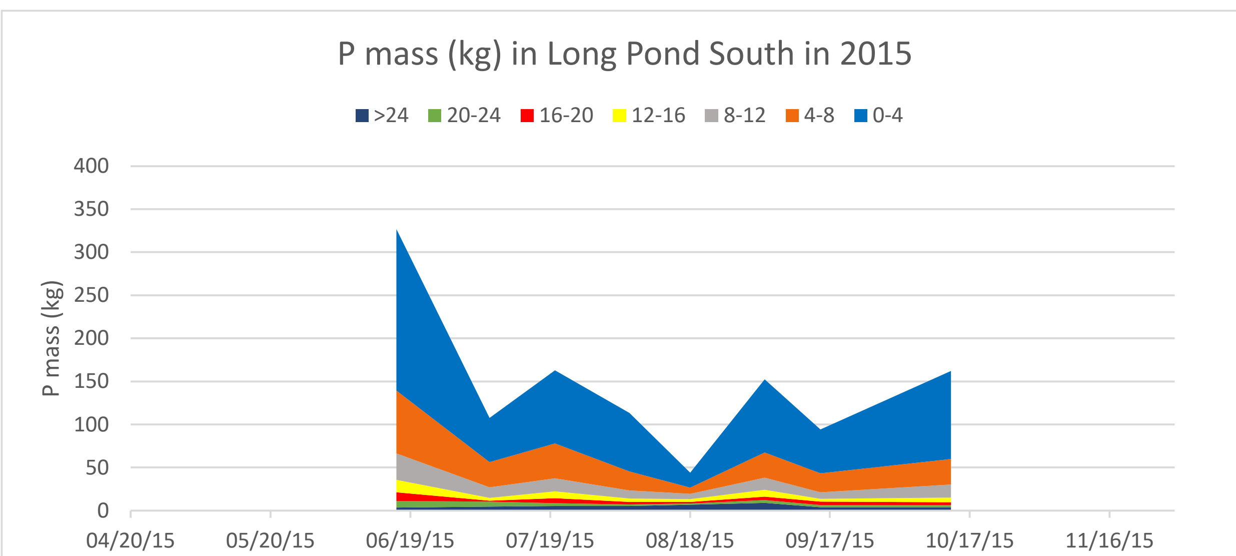
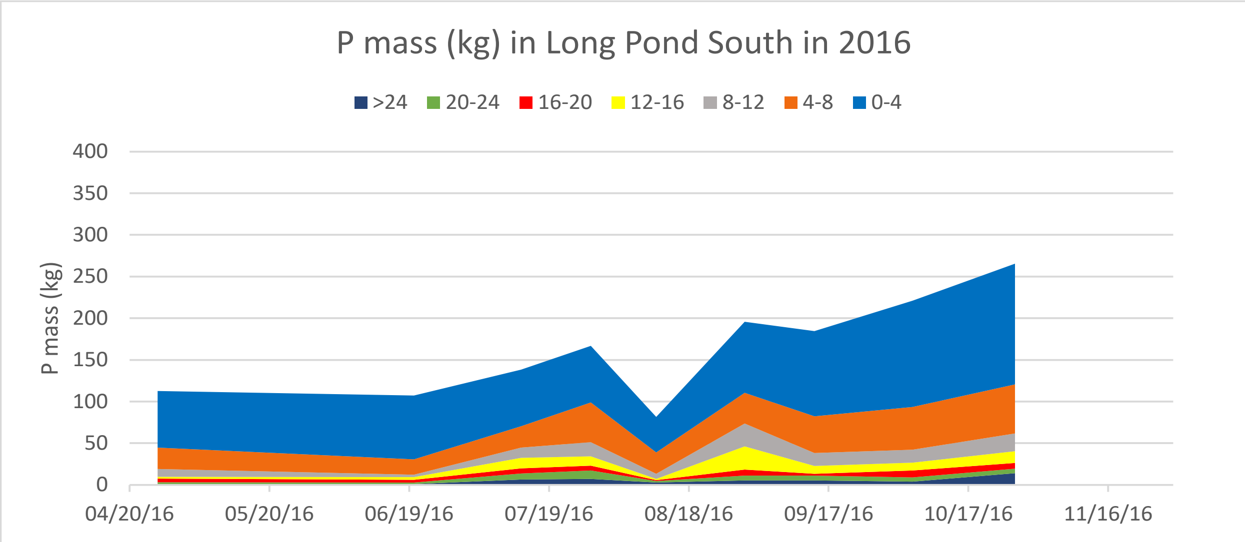
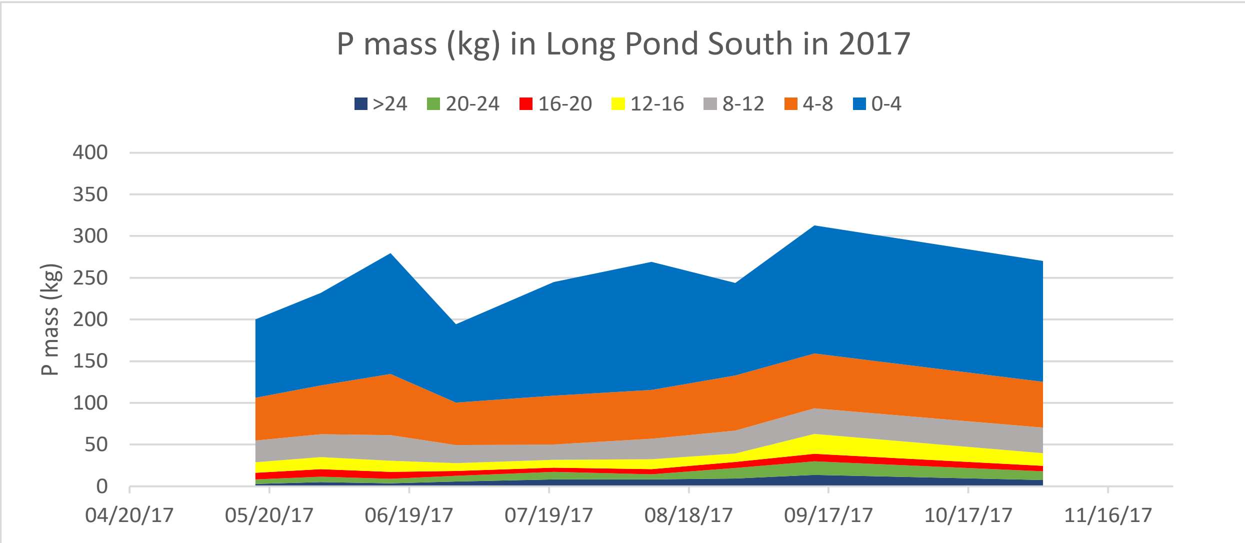


Figure 2. continued





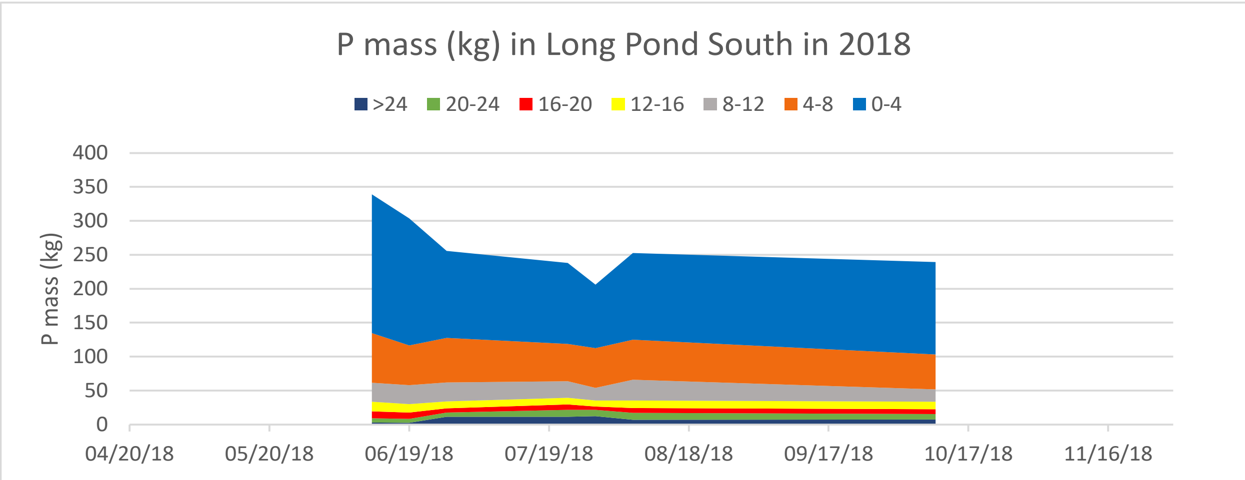
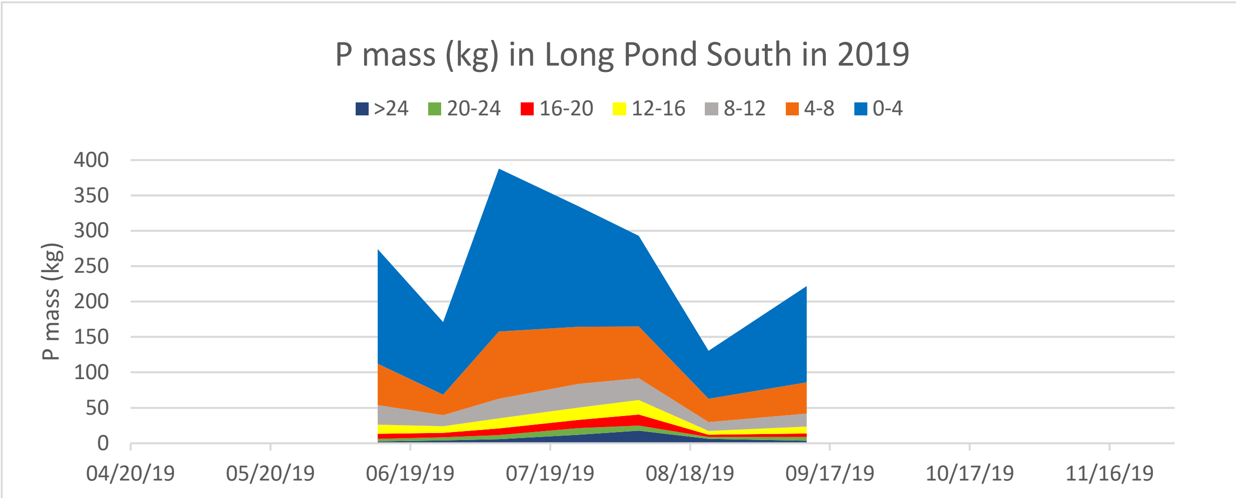
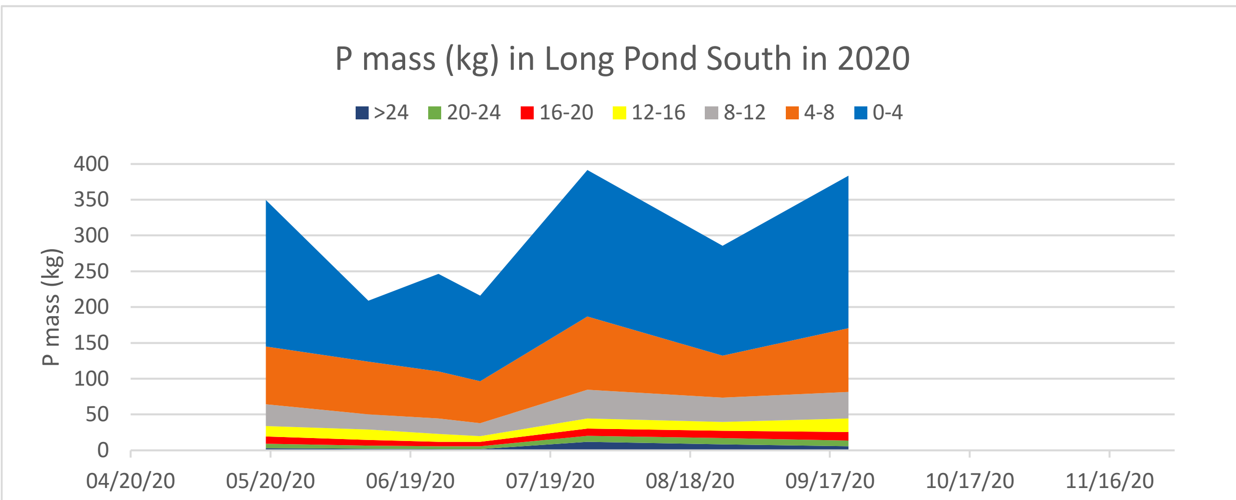
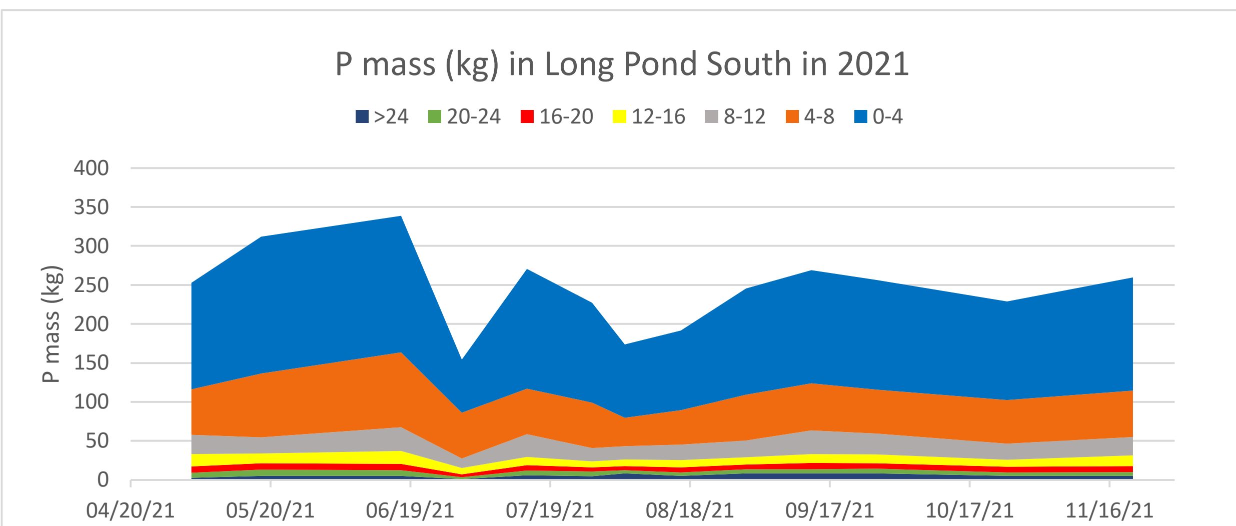


Figure 2. continued







The pattern in each basin varies from year to year but in general there is a decline at some point in June and another at some point in August for the total P mass in each basin. The June decline may be related to settling of diatoms as the water warms and spring phytoplankton peaks wane. The August decline is harder to explain but may relate to cooling at that time in many years and a resultant shift in types of algae with related settling. There may be some sampling and analysis artifacts, but the pattern does hold across basins in a general way.

Also apparent from graphs of P mass is variation in starting point in the spring, often seemingly related to the ending point the year before. There is a period from sometime in November until usually sometime in late April where no data are collected for P, so nutrient dynamics during this winter-spring period are not documented. Yet the P mass in spring tends to be similar to that of the preceding autumn. Both basins experience multiple flushings per year, so this is not a simple matter of the water mass remaining the same.

Most of the P mass is in the upper 8 m of the water column, the epilimnion of both basins. That mass increases and decreases over the course of the growing season, but does not appear strongly impacted by internal loading of P. The deeper water layers show some increase over most summers, indicative of P release from sediment exposed to low oxygen, but the actual P mass in those layers is almost always a minor component of the total P mass in either basin. While flux of P among layers may complicate interpretation of changes in the P mass in any layer over time, the maximum increase over the course of the summer period of low oxygen (Table 6) suggests that the P released from sediments exposed to low oxygen ranges from 24 to 92 kg in the North Basin when the prediction from the 2016 WRS evaluation was 13 to 306 kg. For the South Basin, the estimated range for 2015-2021 is 7 to 32 kg while the 2016 WRS estimate was 13 to 100 kg. The average for the seven years of recent data was 57 kg for the North Basin vs a past estimate of 140 kg and 21 kg for the South Basin compared to a past estimate of 60 kg. Estimates from DEP and consultants prior to 2010 were similar to the WRS 2016 values. While the variation in estimates is large enough to minimize any statistical power for comparisons, it does not appear that internal P loading is increasing.

Table 6. Maximum increase in P mass at >8 m in Long Pond over each summer

	Max hypolimnetic P build-up (kg)	
Year	North	South
2015	24	10
2016	92	24
2017	59	18
2018	43	7
2019	76	29
2020	30	32
2021	76	26
Avg	57	21

The pattern of P mass in each basin may be indicative of watershed inputs, with higher values more common at the start of measurement in spring, indicative of higher inputs during spring. The fluctuations observed over the growing season may relate to the precipitation pattern. The apparent internal loads are simply not great enough to account for the observed increases in P mass in the epilimnion in most cases, even assuming some flux that is not accounted for in simple mass difference measures, and many of those increases come at times of expected minimal internal P loading.

Assessments of overall P concentrations can be derived several ways. Core samples that integrate the epilimnion (the normal DEP approach) are useful for relating P concentration to observed conditions like chlorophyll-a or Secchi transparency. Yet volume weighted P concentration for the whole water column is worth considering and is made possible by the vertical profile sampling by Colby College and the 7 Lakes Alliance. DEP data for 2019-2021 are not yet available and only one or two core samples have been collected per year, compared to 7 - 10 vertical profiles by Colby College and 7 Lakes Alliance. The comparison of these two approaches (Table 7) indicates that there are differences in the results of the two approaches, although all values are <11 µg/L and variation as a function of sampling and testing error could account for the observed differences. The small number of DEP core samples is a limiting factor, given observed variation over time (Figures 1 and 2).

Table 7. Average P concentration over time in Long Pond

	Volume weighted TP (ug/L)		TP from epilimnetic core samples (ug/L)	
Year	North	South	North	South
2015	5.6	4.7	10	5
2016	6.4	5.3	7	8
2017	9.9	9.1	7	7
2018	10.1	8.5	9.5	8
2019	8.0	8.4		
2020	9.6	9.6		
2021	7.8	7.9		
Avg	8.2	7.6		

The annual, volume-weighted P concentrations from multiple spring-fall vertical profiles may be a better measure of average P in Long Pond. One could exclude the deeper water to get a volume weighted epilimnetic P concentration, but the deeper water represents a smaller volume and has elevated P concentrations only later in the growing season, limiting its effect.

Considering the possible reasons for the observed variation in TP in Long Pond, internal loading appears to be a minor factor while surface water inflows may be particularly important. The precipitation record for the area, based on the weather station at the Bangor airport (Table 8) shows a substantial range of monthly and annual precipitation between 2015 and 2021. The precipitation records for the Augusta airport and the Waterville treatment facility are similar to that for Bangor with <1 inch more total annual precipitation for the targeted period.

Table 8. Precipitation record for the Long Pond area

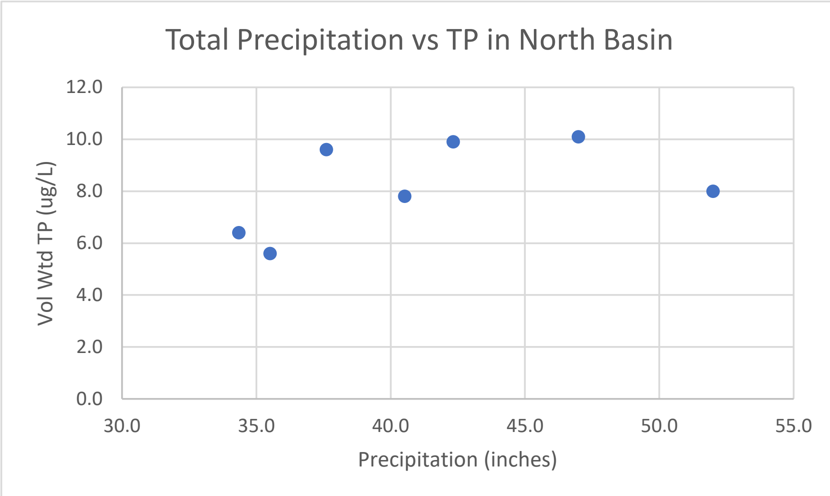
	Inches of precipitation						
Month	2015	2016	2017	2018	2019	2020	2021
Jan	2.67	2.38	3.63	5.53	5.15	2.42	1.39
Feb	2.20	3.89	2.26	2.99	1.83	1.65	1.99
Mar	1.45	3.27	2.07	2.18	1.94	2.27	1.76
Apr	2.39	2.58	3.98	4.77	5.53	4.78	3.63
May	2.32	2.09	6.36	2.37	4.43	2.22	1.82
Jun	4.90	2.85	4.32	5.42	5.33	2.08	0.97
Jul	1.16	2.69	1.91	2.48	4.46	4.21	7.67
Aug	2.63	2.24	1.64	2.73	7.54	3.55	1.78
Sep	6.89	1.23	3.69	2.63	2.81	0.28	9.42
Oct	2.58	3.20	5.59	4.66	5.80	4.40	4.45
Nov	2.26	4.16	3.05	7.00	3.97	5.22	3.44
Dec	4.06	3.77	3.83	4.23	3.21	4.52	2.20
Total	35.51	34.35	42.33	46.99	52.00	37.60	40.52
Apr-Aug	13.40	12.45	18.21	17.77	27.29	16.84	15.87

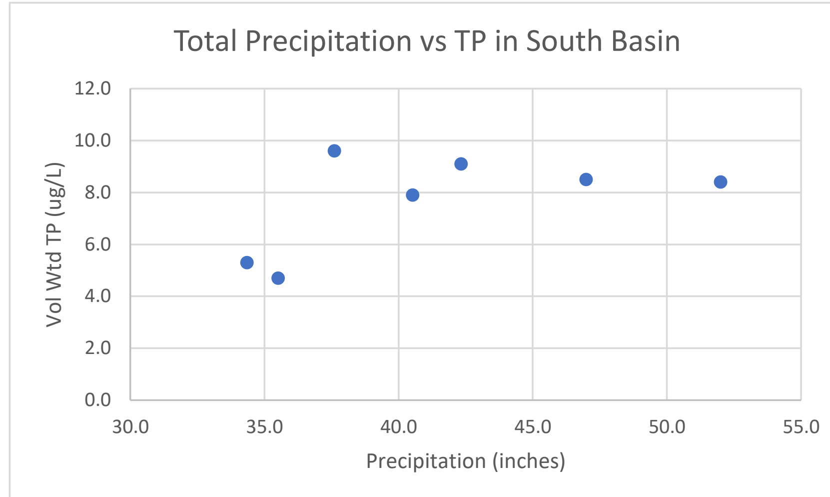
Comparing the volume weighted P concentrations for the North and South Basins with either annual precipitation or that from just the April-August period (Figure 3), the relationship between P and total annual precipitation is positive but weak, while the relationship between P and April-August precipitation is very strong except for one outlier point representing 2019. Precipitation in 2019 was by far the highest for the 2015-2021 period and there may be a "wash-out" phenomenon whereby P inputs are diluted when there is that much rain.

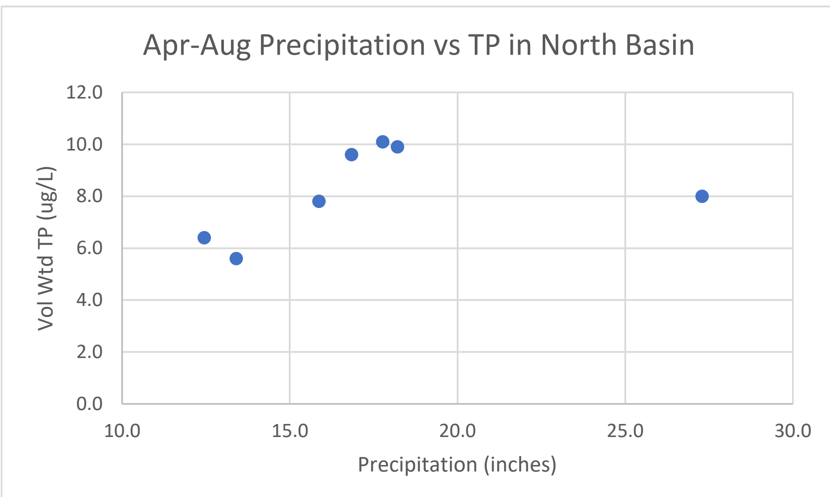
These results suggest that precipitation interacting with watershed features are likely to be the most important determinants of in-lake P concentration in both basins of Long Pond. This relationship would likely be obscured if the detention time for water in Long Pond was longer, but with multiple flushings per year, the influence of the watershed becomes more evident. More precipitation brings more P to the lake. With climate change having increased precipitation in New England over the last 50 years and expected to continue to do so, watershed management becomes even more important to protecting the lake.

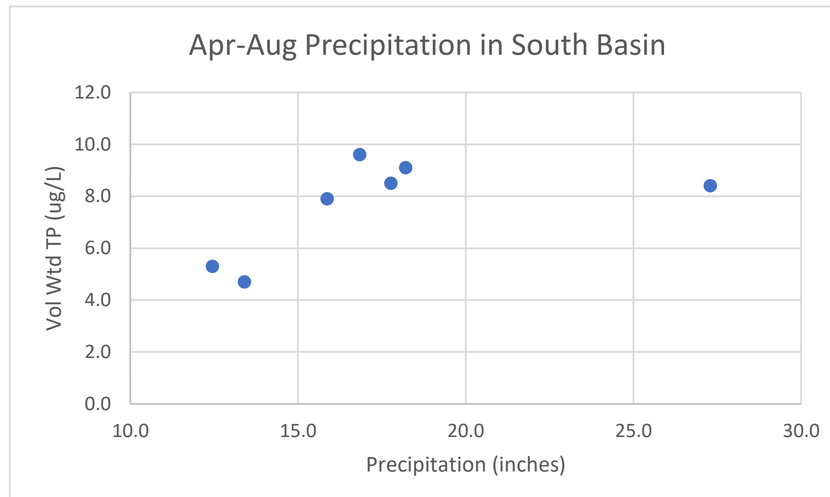
There is enough variation among years, likely related to precipitation pattern, that any trend for phosphorus over time would be obscured without looking at a much longer period of time or somehow normalizing for precipitation effects in any year. Additionally, the intensity of storms, also predicted to increase as a function of climate change, is not considered in this analysis. Yet the influence of increased precipitation on in-lake P concentration is quite apparent in Figure 3. Combined with ongoing development within the watershed, a negative influence on the lake is expected without substantial watershed measures to curtail loading.

Figure 3. Precipitation vs phosphorus concentration in Long Pond, 2015-2021









The WRS 2016 assessment included the use of empirical models to back-calculate the load of P necessary to produce the observed P concentrations in each basin of Long Pond and compared those loads to the best empirical estimates that could be derived for defined drainage areas or other sources (e.g., atmospheric inputs, groundwater/wastewater flows, internal load; Table 1). However, those models used bathymetric data available at the time and the new bathymetry appears to alter area, volume, and mean depth enough to affect the results.

Working through the empirical models in both directions to get agreement between total P load and actual P concentration within the context of the current estimates of area and volume, new estimates of the average P load are derived (Table 9). The best estimate of average P load to the North Basin of Long Pond from the WRS 2016 analysis was 1728 kg/yr with a probable range of 1204 to 2410 kg/yr, compared to 1476 kg/yr from the application of empirical models in this assessment. The best estimate of average P load to the South Basin of Long Pond from the WRS 2016 assessment was 1903 kg/yr with a probable range of 1413 to 2506 kg/yr, compared to 1543 kg/yr from this assessment. The current best estimates of average loading to each basin are within the previously expected range but are lower than the previous best estimates.

Table 9. Model parameter values and results

Feature	Units	North	South
Lake Total Phosphorus Conc.	ppb	8.2	7.7
Phosphorus Load to Lake	g P/m2/yr	0.287	0.376
Phosphorus Load to Lake	kg/yr	1476	1543
Influent (Inflow) Total Phosphorus	ppb	11.9	10.2
Inflow	m3/yr	124200000	150900000
Lake Area	m2	5100000	4100000
Lake Volume	m3	38300000	31000000
Mean Depth	m	7.510	7.56
Flushing Rate	flushings/yr	3.243	4.868

Applying the range of concentrations observed over the last 7 years (Table 7), the load to the North Basin is likely to range from 995 to 1838 kg/yr while the load to the South Basin is likely to range from 942 to 1967 kg/yr. The range of expected P loads has been shifted down from the 2016 and earlier estimates but still has considerable overlap. This is a function of additional data collection and analysis, not any actual decrease in loading. Any conclusion about the balance between ongoing development and watershed management efforts are not supported by this analysis, but it appears that P loading to Long Pond has not increased measurably in recent years.

Revisiting the itemized loading analysis from 2016, changes are justified based on new calculations of lake and watershed areas and more recently available data (Table 10). From this new assessment, the average P load is 1463 kg/yr to the North Basin and 1560 kg/yr to the South Basin, very similar to the average loads derived from the empirical models. The only loading category with no change is waterfowl inputs, for which there are no real data. All other input

Table 10. Itemized loading from TMDL, 2016 assessment, and 2022 analysis.

Source	Water (MM3/yr) 2016 Avg	Water (MM3/yr) 2022 Avg	P Load (kg/yr) TMDL	P Load (kg/yr) 2016 Avg	P Load (kg/yr) 2022 Avg	2022 vs 2016 Notes
North Basin						
Direct Precipitation	5.8	5.3	87	120	111	41.33 inches rain (2015-2022), reduced lake area
Direct Groundwater (incl septics)	1.9	1.9	209	125	138	Used revisited 2016 analysis with older data + 10% P
Surface Flow						
Direct Drainage	12.6	12.6	617	271	176	TP reduced from 20 to 13 ppb
Great Indirect Drainage	96.5	96.5	1123	897	868	GP outlet TP reduced from 9.3 to 9.0 ppb
Whittier Indirect Drainage	6.6	6.6		104	52	TP reduced from 20 to 10 ppb
Kidder Indirect Drainage	1.3	1.3		21	11	TP reduced from 20 to 10 ppb
Discharges	0.0	0.0	0	0		No permitted discharges
Waterfowl	0	0	0	50	50	Accepting 2016 calcs, no real data involved
Internal Release	0	0	108	140	57	Recalc using 2015-2021 data
Total North Basin	124.6	124.2	2144	1728	1463	Variation of +/- 10-20% likely among years
South Basin						
Direct Precipitation	5.75	4.26	86	120	89	41.33 inches rain (2015-2022), reduced lake area
Direct Groundwater (incl septics)	1.85	1.42	54	125	56	2016 analysis with 23.4% reduced contrib area + 10% P
Surface Flow						
Direct Drainage	17.4	13.3	559	375	287	Reduced area and load by 23.4%; dropping outlet area
From North Basin	121.6	121.3	2008	1010	973	Minimally reduced flow X TP=8.0 ppb
Ingham Indirect Drainage	10.3	10.6		163	84	Slightly larger watershed than 2016, TP reduced from 20 to 10 ppb
Discharges	0	0	0	0	0	No permitted discharges
Waterfowl	0	0	0	50	50	Accepting 2016 calcs, no real data involved
Internal Release	0	0	65	60	21	Recalc using 2015-2021 data
Total South Basin	156.9	150.9	2772	1903	1560	Variation of +/- 10-20% likely among years

categories are adjusted based on new information. Most changes are decreases. The only notable increase is ground water inputs, including septic systems, as the previous estimates represent data from almost two decades ago and there has been considerable development in the interim.

The best estimate for surface water load has been decreased by 14% to the North Basin and 13% to the South Basin. That surface water load is divided between four sources for the North Basin and three sources for the South Basin. Yet by far the largest North Basin source in each analysis is outflow from Great Pond, currently estimated at 59% of total P load. The largest South Basin source is flow from the North Basin, currently estimated at 62%. While addressing the P load from all surface drainage sources is warranted, the obvious primary target for load control is the outflow from Great Pond. This analysis has not changed that primary management conclusion from the 2016 and earlier efforts.

Future Loading Scenarios

For management planning it is desirable to consider possible future loading scenarios. These could include changes due to climate change, development, and management efforts (Table 11). Considered here are the changes to the current water and P loading induced by climate change that increases precipitation by 2% and 10%, by a decade of increased development at the anticipated rate, with and without runoff controls, and management of all known problem parcels in the watershed, including mainly residential properties and roads. The assumptions associated with each scenario are provided below the table. Variation is not addressed and could be substantial, certainly +/- 10% as expected for the total load, and possibly more when considering climate change. It is appropriate to focus on the direction and magnitude of change, not the actual numbers and certainly not to a decimal place.

The key factors in climate change are increasing temperature and precipitation. The influence of precipitation is heightened by increasing intensity of storms. There may actually be longer periods of dry weather punctuated by larger storms that raise the average annual precipitation. Aside from the increased runoff and associated P loading accompanying storms, the dry periods may be longer, raising the average temperature of lake water. Warmer water favors cyanobacteria as a function more efficient metabolism at higher temperatures. Warmer water near the sediment will accelerate decomposition, raising oxygen demand and potentially increasing internal P loading. As the N:P ratio of that internal load is almost always <10, cyanobacteria are again favored.

For development, the key factors are impervious surface leading to more runoff and residential practices leading to more P available to be washed into streams and lakes. Roads, roofs, driveways, and even lawns on packed soils shift the fate of precipitation from infiltration to runoff. Fertilization and lawn waste (e.g., grass, leaves) handling can lead to higher organic and P loading to water resources. Best management practices are intended to minimize impacts by source control and pollutant trapping, but even the best controls do not completely counter development impacts. Yet where development has not been subject to controls, application of controls can provide loading reductions throughout the watershed that can be larger than the new loading from limited new development.

Table 11. Results of modeling possible future scenarios for Long Pond.

			Climate Change				Watershed Build-out		Watershed Mgmt
	Current (2022) Conditions		2% more precip		10% more precip		With controls	Without controls	Practical BMP application
Source	Water	P Load	Water	P Load	Water	P Load	P Load	P Load	P Load
	(MM3/yr)	(kg/yr)	(MM3/yr)	(kg/yr)	(MM3/yr)	(kg/yr)	(kg/yr)	(kg/yr)	(kg/yr)
North Basin									
Direct Precipitation	5.3	111	5.4	113	5.9	122	111	111	111
Direct Groundwater (incl septics)	1.9	138	1.9	139	2.1	144	151	151	124
Surface Flow									
Great Indirect Drainage	96.5	868	98.4	885	106.2	955	871	873	814
Direct Drainage	12.6	176	12.9	180	13.9	194			160
Whittier Indirect Drainage	6.6	52	6.7	53	7.3	57	240	245	50
Kidder Indirect Drainage	1.3	11	1.3	11	1.4	12			11
Waterfowl	0	50	0.0	51	0.0	55	50	50	50
Internal Release	0	57	0.0	58	0.0	63	57	57	57
Total North Basin (kg)	124.2	1463	126.7	1490	136.6	1602	1480	1488	1377
Total North Basin (g/m2/yr)		0.287		0.292		0.314	0.290	0.292	0.270
North Basin Avg TP (ug/L)		8.2		8.2		8.3	8.3	8.4	7.7
North Pond Avg Chl-a (ug/L)		2.2		2.2		2.3	2.3	2.3	2.1
North Pond Prob of Chl-a.8 ug/L (%)		0.3		0.3		0.3	0.3	0.3	0.1
South Basin									
Direct Precipitation	4.26	89	4.3	91	4.7	98	89	89	89
Direct Groundwater (incl septics)	1.42	56	1.4	57	1.6	59	62	62	50
Surface Flow									
From North Basin	121.3	973	123.7	992	133.4	1070	982	986	913
Direct Drainage	13.3	287	13.6	293	14.6	316	373	377	265
Ingham Indirect Drainage	10.6	84	10.8	86	11.7	92			74
Waterfowl	0	50	0.0	51	0.0	55	50	50	50
Internal Release	0	21	0.0	21	0.0	23	21	21	21
Total South Basin (kg)	150.9	1560	153.9	1591	166.0	1713	1576	1585	1462
Total South Basin (g/m2/yr)		0.381		0.388		0.418	0.384	0.387	0.357
South Basin Avg TP		7.8		7.8		7.8	7.8	7.9	7.3
South Pond Avg Chl-a (ug/L)		2.1		2.1		2.1	2.1	2.1	1.9
South Pond Prob of Chl-a.8 ug/L (%)		0.2		0.2		0.2	0.2	0.2	0.1

Scenario Notes:	
2% and 10% precipitation increase from climate change	2% or 10% increase in precipitation and runoff with commensurate P load increases, half that increase for groundwater, 2% or 10% increase in waterfowl and internal loading based on temperature increases, represents range of expected influence over coming 1-5 decades
Watershed build-out with controls	Assumes 10 years of projected 100-yr build-out with maximum runoff BMP implemented, 2.9 kg P increase from drainage areas except Great Pond, split evenly between N and S basins, 41.6% of 6.5 kg P load increase to Great Pond reaches Long Pond north basin. Septic system influence increased by 10%.
Watershed build-out without controls	Assumes 10 years of projected 100-yr build-out with no runoff BMP implemented, 12 kg P increase from drainage areas except Great Pond, split evenly between N and S basins, 41.6% of 13 kg P load increase to Great Pond reaches Long Pond north basin. Septic system influence increased by 10%.
Watershed Management	All known NPS issues addressed in watershed, leading to reduction of 0 kg from Kidder, 2 kg from Whittier, 16 kg from north basin direct, 10 kg from Ingham and 22 kg from south basin direct. 41.6% of Great Pond reduction of 130 kg from WBP lost from Long Pond north basin. Septic system influence reduced 10%. No change in internal loading assumed.

Average total P, average chlorophyll-a (representing algae), and the probability of having an algae bloom (defined as chl-a >8 µg/L) do not change greatly among the scenarios (Table 11). The amount of change in precipitation or development over a decade is not large enough to shift conditions in either basin of Long Pond markedly. Extended out over a period of 50 or 100 years, the direction of change for either climate change or expanded development is toward greater P loading and more algae and would be noticeable, but current management plans focus on a decade of action. What could be accomplished in terms of non-point source controls over the next decade would lower P and chlorophyll-a in Long Pond more than climate change or development would raise it over the same period. From this exercise, maximum best management practice implementation could counter both maximum expected climate change impacts and the influence of expected development together.

Application of best management practices for controlling the amount and quantity of runoff in the watershed of Long Pond, including upstream lakes, could reduce the P concentration by 0.5 µg/L while anticipated increases due to climate change or development range from 0 to 0.2 µg/L. Bloom probability is currently very low but watershed management could cut that probability by two thirds for the North Basin and in half for the South Basin. Yet all these values are too small to accurately measure in any reasonable monitoring program. Derived from models, the changes represent reality but are subject to error and the statistical power to detect real changes is limited. What is clear is that without management, Long Pond will suffer increased P loading and resultant increases in algal abundance, albeit over a long period of time. However, rapid reversal of conditions will be challenging, and continued diligence with regard to watershed management is the best policy for maintaining desirable conditions in Long Pond.

One factor not considered in this modeling exercise is a common mode of cyanobacteria bloom development, that being growth at the sediment-water interface where available sediment P is adequate and light penetration is sufficient, with subsequent development of gas pockets in cells and a synchronous rise in the water column to form a surface bloom. *Gloeotrichia*, *Dolichospermum*, and *Microcystis,* all problem types of cyanobacteria, are known to form blooms by this benthic initiation mechanism. Blooms that develop by this mode do not depend on P in the water column to get started and will act as a vector for transport of P from sediment to the surface waters. Those blooms may not last more than a week or two in low P surface waters, but this process will lead to higher internal P loading and transport into upper waters, accelerating eutrophication.

A majority of the P inputs in any year wind up in the sediment and become the source of internal P loading. Data from a recent 7-year period suggest that internal P loading is low in both basins of Long Pond, but the benthic mode of cyanobacteria bloom formation does not depend on the P getting into the water column, just being available at the sediment-water interface, mostly as a function of low oxygen. The threat of such blooms is expected to track the Anoxic Factor (AF), which quantifies the extent and duration of low oxygen at the sediment-water interface. Any increase in AF and onset of such blooms is an indication that loading of P, organic matter, and other contaminants from the watershed are too high and likely have been too high for some years. Ongoing management to minimize such inputs is important, rather than trying to fix a larger problem once it occurs. The difficulty in this approach lies in getting the public in general and decision makers in particular to recognize the value of preventive action over remediation.